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June 1972

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Volume 13, Number 4, April 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

2

Distribution of Cesium-137 and Naturally Occurring Radionuclides in Sediments of Lake Michigan[1]

Philip A. Plato[2]

Measurements of radioactivity in bottom sediments of Lake Michigan were made during 1969 and 1970. The only manmade radionuclide found was cesium-137 which originated from over two decades of atmospheric testing of nuclear weapons. A correlation was observed between accumulation of cesium-137 in sediments and water current patterns in Lake Michigan. Concentrations of naturally occurring potassium-40 and radium-226 were found to correlate with the type of sediment present.

Ten nuclear power reactors are scheduled for operation on Lake Michigan by 1976. The plants are owned by six power companies which formed "The Lake Michigan Utility Study Group" in order to study problems common to all the nuclear plants.

The Radiological Health Section of the University of Michigan conducted a study for the Lake Michigan Utility Study Group during 1969 and 1970 designed to measure radioactivity present in Lake Michigan before the majority of the nuclear plants become operational.[3] Approximately 400 samples of lake water, bottom sediment, phytoplankton, zooplankton, and benthos were collected and analyzed for radioactivity (*1*). Accumulation patterns, described in this paper, were observed for cesium-137, potassium-40, and radium-226 in the bottom sediments of the lake. Little or no radioactivity was detected in samples of the other environmental media.

Collection and analysis of sediment

Samples of sediment were collected at the 50 sampling stations shown in figure 1, which also shows locations, generating capacities and scheduled dates of operation of the 10 nuclear plants.

Sediment samples were collected with a Ponar dredge. The dredge collects sediment over a surface area of about 1,000 cm^2 to a depth of about 5 cm. Three samples were collected at most stations during three cruises of the University of Michigan's research vessel *Mysis*. The cruises were made during August and October 1969, and April 1970.

The samples were shipped to the Radiological Health Section of the University of Michigan for radioactivity analyses. Each sample was oven-dried at 110°C for 24 hours and transferred to a plastic counting container. The con-

---

[1] This research was supported by the Lake Michigan Utility Study Group, an ad hoc group comprised of representatives from American Electric Power Service Corporation, Commonwealth Edison Company, Consumers Power Company, Northern Indiana Public Service Company, Wisconsin Electric Power Company, and Wisconsin Public Service Corporation.

[2] Dr. Plato is assistant professor of radiological health in the Department of Environmental and Industrial Health, School of Public Health, The University of Michigan, Ann Arbor, Michigan.

[3] The Big Rock Point Nuclear Power Plant was the only operational reactor on Lake Michigan when this project was conducted. The Big Rock Point Plant will represent only 1 percent of the nuclear power produced on Lake Michigan by 1976.

3

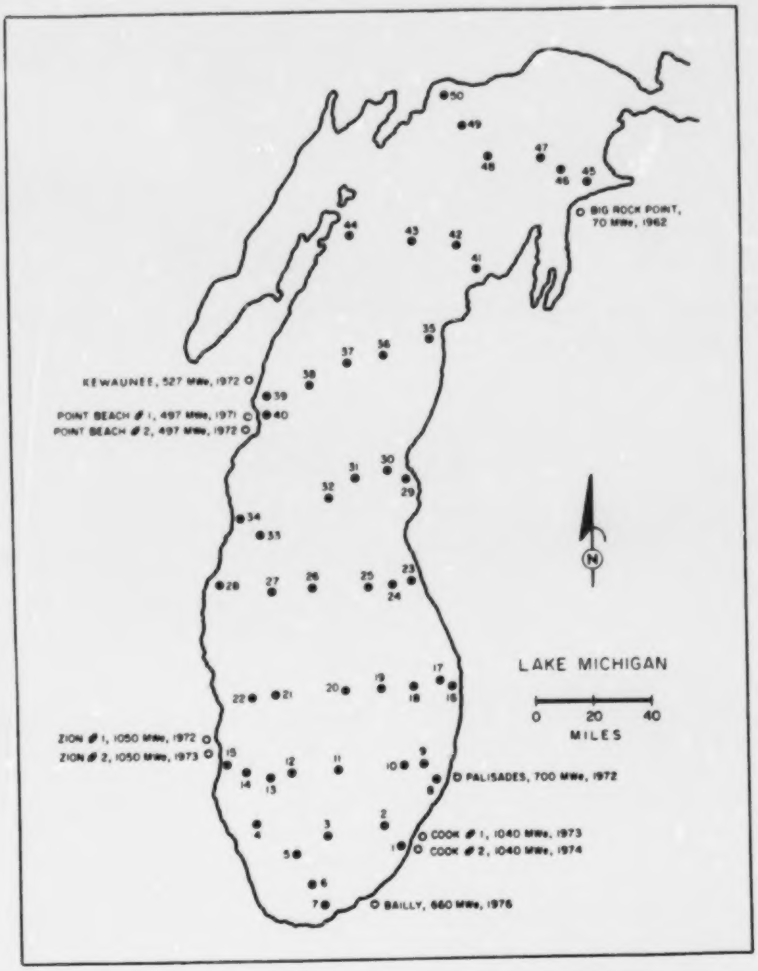
50
49
48
47
46
45
BIG ROCK POINT, 70 MWe, 1962
44
43
42
41
35
36
37
38
KEWAUNEE, 527 MWe, 1972
39
POINT BEACH # 1, 497 MWe, 1971
40
POINT BEACH # 2, 497 MWe, 1972
31
30
32
29
34
33
N
28
27
26
25
24
23
LAKE MICHIGAN
17
19
20
21
22
18
16
0
20
40
MILES
ZION # 1, 1050 MWe, 1972
ZION # 2, 1050 MWe, 1973
15
14
13
12
11
10
9
8
PALISADES, 700 MWe, 1972
4
3
2
COOK # 1, 1040 MWe, 1973
COOK # 2, 1040 MWe, 1974
1
5
6
7
BAILLY, 660 MWe, 1976

Figure 1. Sediment sampling stations in Lake Michigan (locations, generating capacities, and scheduled dates of operation of nuclear power plants)

tainers measure 10 × 10 × 6 cm and have snap-on tops.

A gamma-ray spectrum was obtained for each sample with a 12.5 × 10.0 cm (5 × 4 inch) NaI solid crystal and a 256-channel pulse height analyser. Spectra were stored on magnetic tape, and a spectrum analysis computer program (*2*) was used to make quantitative measurements of radionuclides present in each spectrum.

Cesium-137 was the only manmade radionuclide detected in any of the sediment samples. Naturally-occurring potassium-40 and radium-226 in equilibrium with its daughters were detected in the samples. Table 1 shows the concentrations of cesium-137 in each sample of sediment and average concentrations for each station.

It is reasonable to assume that all of the cesium-137 detected originated from fallout

4

Table 1. Cesium-137 concentrations in samples of bottom sediment taken from Lake Michigan

Station number	Cesium-137 concentration (pCi/g ±standard deviation)[a]			
	Sample 1	Sample 2	Sample 3[b]	Average
1	0.16 ±0.08	0.13 ±0.04		0.15 ±0.02
2	8.07 ± .32	.29 ± .07		4.18 ±3.89
3	4.14 ± .21	3.44 ± .17		3.79 ± .35
4	.56 ± .04	.62 ± .04	0.84 ±0.05	.67 ± .12
5	1.29 ± .08	.52 ± .05	1.12 ± .07	.97 ± .33
6	1.02 ± .06	.83 ± .04	2.60 ± .13	1.48 ± .79
7	.49 ± .04	.08 ± .03	.75 ± .05	.44 ± .27
8	.20 ± .06	.09 ± .02		.14 ± .05
9	1.53 ± .18	.31 ± .03		.92 ± .61
10	1.37 ± .21	2.20 ± .13		1.78 ± .41
11	2.87 ± .20	2.59 ± .26		2.73 ± .14
12	1.90 ± .13	2.62 ± .16	5.86 ± .23	3.46 ±1.72
13	4.18 ± .17	4.19 ± .17	2.22 ± .22	3.53 ± .93
14	1.91 ± .10	3.78 ± .15	.99 ± .06	2.23 ±1.16
15	.14 ± .08	.17 ± .05	.23 ± .07	.18 ± .04
16	.24 ± .03	.67 ± .05		.45 ± .22
17	6.18 ± .25	4.17 ± .21		5.17 ±1.01
18	.88 ± .11	.53 ± .09	1.67 ± .13	1.03 ± .48
19	3.12 ± .22	4.13 ± .17	4.29 ± .17	3.85 ± .52
20	1.73 ± .28	1.09 ± .11	1.31 ± .12	1.38 ± .26
21	2.63 ± .13	1.66 ± .08		2.15 ± .48
22	1.36 ± .07	.96 ± .07	1.05 ± .07	1.12 ± .17
23	.83 ± .06	1.26 ± .08	1.13 ± .14	1.07 ± .18
24	.93 ± .10	2.39 ± .14		1.66 ± .73
25	2.75 ± .16	5.41 ± .22	1.23 ± .11	3.13 ±1.73
26	1.16 ± .09	1.33 ± .08	.49 ± .03	.99 ± .36
27	2.75 ± .14	1.88 ± .11	3.20 ± .13	2.61 ± .55
28	.73 ± .05	1.30 ± .08	.79 ± .06	.94 ± .25
29	.12 ± .02	.14 ± .02	.23 ± .03	.16 ± .05
30	.83 ± .06	.76 ± .05	1.37 ± .12	.99 ± .27
31	3.10 ± .19	5.44 ± .33	3.91 ± .20	4.15 ± .97
32	1.40 ± .24	.87 ± .10	.61 ± .12	.96 ± .33
33	2.44 ± .12	.44 ± .07	2.12 ± .17	1.67 ± .88
34	.56 ± .05	.58 ± .05	1.01 ± .06	.72 ± .21
35	.50 ± .05	.60 ± .10	.77 ± .06	.62 ± .11
36	.17 ± .14	.49 ± .13	1.02 ± .12	.56 ± .35
37	.22 ± .10	1.57 ± .14	.25 ± .07	.68 ± .63
38	.18 ± .12	.57 ± .16		.37 ± .20
39	1.00 ± .06	.70 ± .05	.85 ± .05	.85 ± .12
40	.17 ± .03	.25 ± .03		.21 ± .04
41	.94 ± .08	.20 ± .07	1.00 ± .08	.71 ± .36
42	1.55 ± .08	.84 ± .08	.62 ± .04	1.00 ± .40
43	.13 ± .10	.14 ± .10		.13 ± .12
44	.99 ± .07	1.00 ± .07		.99 ± .08
45	1.50 ± .09	1.21 ± .06	3.06 ± .15	1.92 ± .81
46	.66 ± .07	1.02 ± .05	2.80 ± .17	1.49 ± .93
47	.43 ± .06	1.34 ± .07	.42 ± .04	.73 ± .43
48	.25 ± .09	1.05 ± .27	.10 ± .07	.47 ± .42
49	.15 ± .07	.19 ± .08		.17 ± .02
50	.42 ± .05	.09 ± .03		.25 ± .16

[a] Errors calculated for each sample represent counting errors at the one sigma level. Errors calculated for average concentrations are sample standard deviations.

[b] A third sample was not collected at every station.

from atmospheric tests of nuclear weapons. Gustafson and Miller (*3*) indicate approximately 15,000 curies of fallout cesium-137 entered the Lake Michigan watershed between 1950 and 1970. The Big Rock Point Nuclear Power Plant discharged less than 6 curies of cesium-137 (approximately 0.04 percent of the cesium-137 that originated from fallout) into Lake Michigan between 1962 and 1970.[4]

Discussion

Figure 2 shows average concentrations of cesium-137 in sediment according to station location. Contour lines of equal concentration, also shown in figure 2, indicate distinct accumulation patterns of cesium-137 in the sediments of the southern half of the lake.

Figure 3 shows surface water current patterns observed in Lake Michigan (*4*) together with cesium-137 contour lines established in figure 2. The Waukegan-Chicago-Gary area, a

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[4] R. Sinderman. Consumers Power Company, Jackson, Michigan. Personal communication, November, 1971.

5

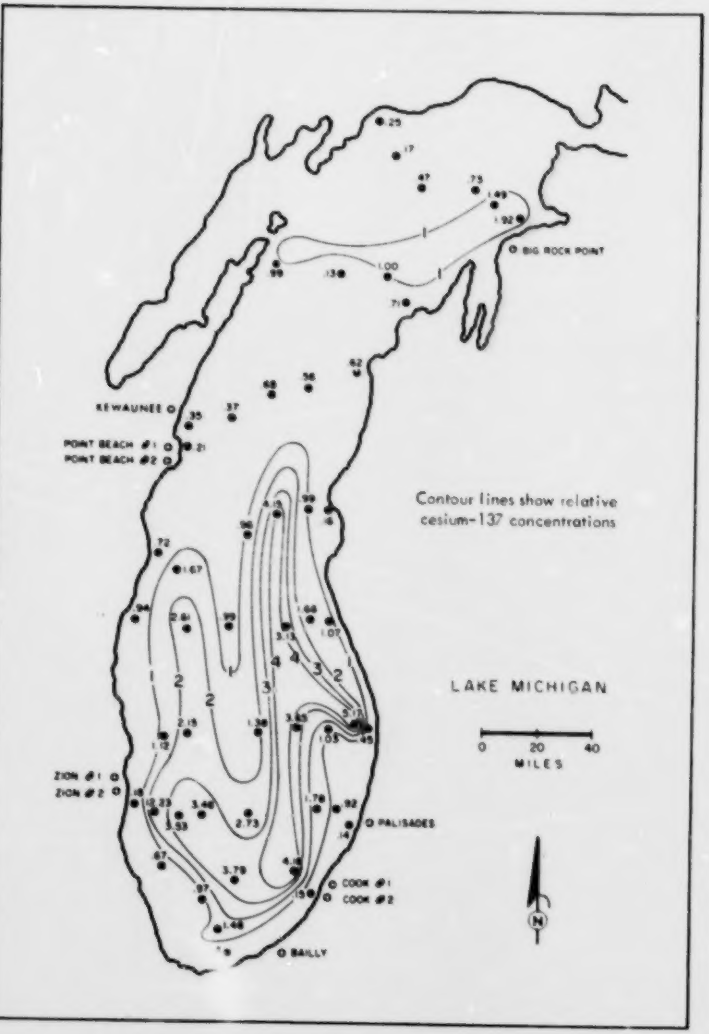

.25
.17
.47
.73
1.49
1.92
BIG ROCK POINT
1
.99
.13
1.00
.71
.62
.68
.56
.37
.35
KEWAUNEE
POINT BEACH #1
.21
POINT BEACH #2
Contour lines show relative cesium-137 concentrations
4.15
.99
.16
.96
.72
1.67
.94
2.61
.99
1.68
3.13
1.07
1
2
2
3
4
4
3
2
1
5.17
2.15
1.38
3.65
1.12
1.03
.45
LAKE MICHIGAN
0
20
40
MILES
ZION #1
ZION #2
.18
12.23
3.46
3.53
2.73
1.78
.92
PALISADES
.14
.67
3.79
4.15
COOK #1
.97
.15
COOK #2
1.48
.19
BAILLY
N

Figure 2. Average concentrations (pCi/g) of cesium-137 measured at each sediment sampling station in Lake Michigan (*1*)

6

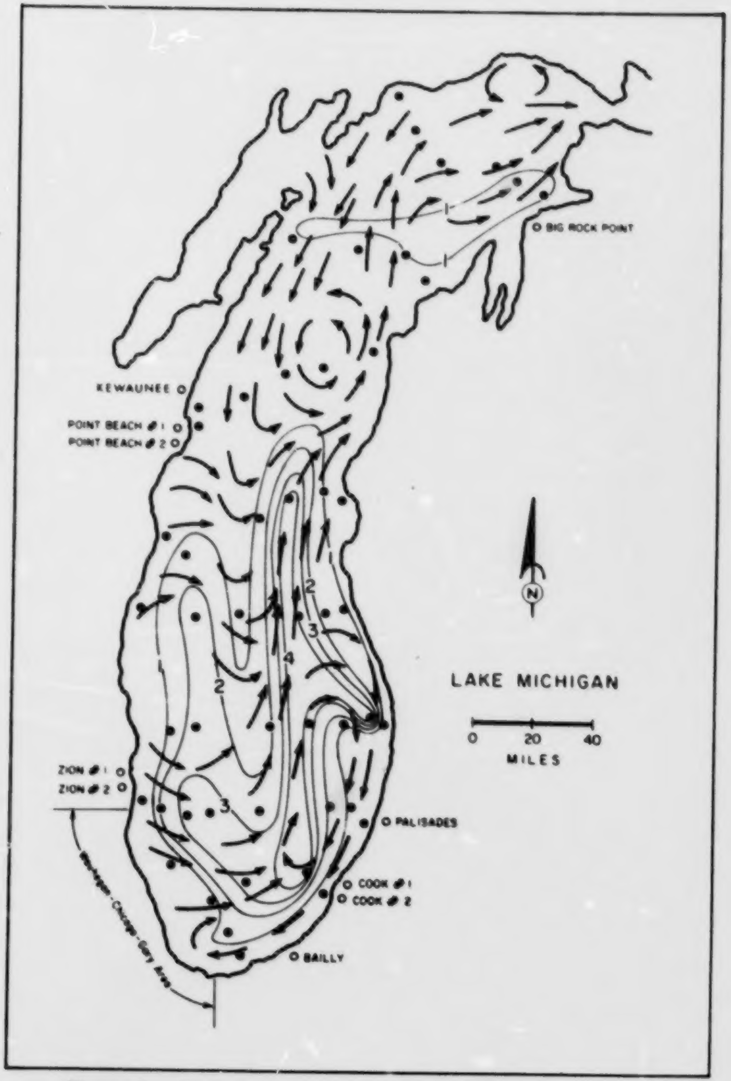

BIG ROCK POINT
1
KEWAUNEE
POINT BEACH #1
POINT BEACH #2
2
3
4
2
3
N
LAKE MICHIGAN
0
20
40
MILES
ZION #1
ZION #2
Waukegan-Chicago-Gary Area
PALISADES
COOK #1
COOK #2
BAILLY

Figure 3. Surface water current patterns (arrows) (*4*) and cesium-137 accumulation patterns in pCi/g of sediment

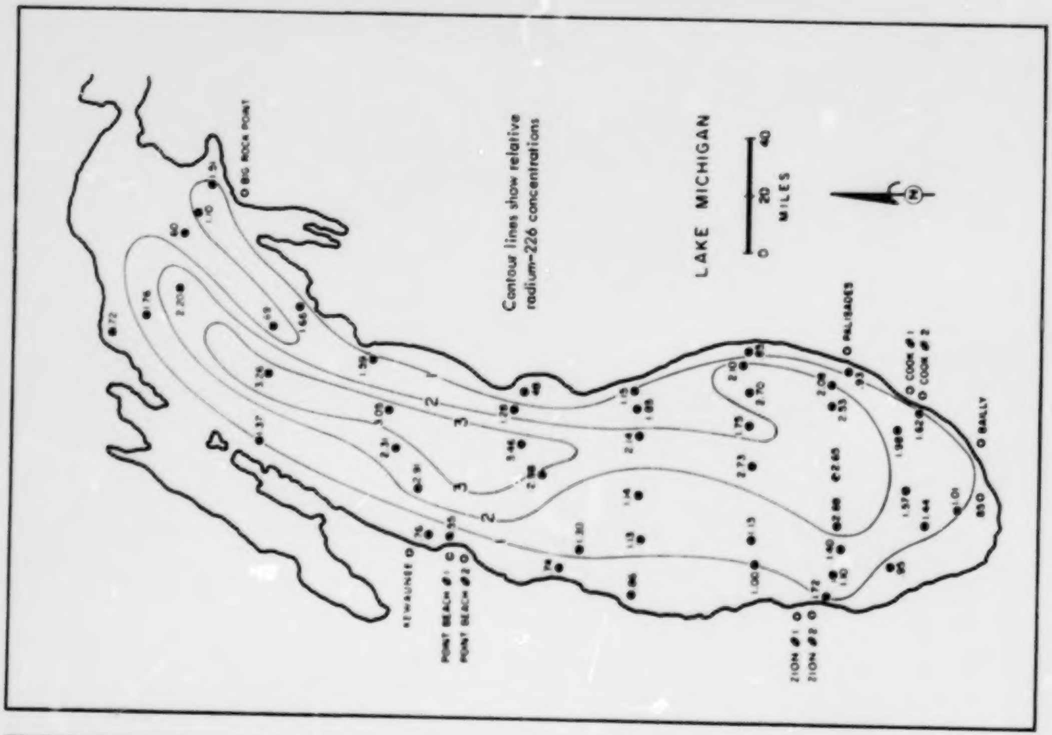

Contour lines show relative radium-226 concentrations
LAKE MICHIGAN
0 20 40
MILES
N
BIG ROCK POINT
KEWAUNEE
POINT BEACH #1
POINT BEACH #2
ZION #1
ZION #2
PALISADES
COOK #1
COOK #2
BAILLY
2
3

Figure 5. Average concentrations (pCi/g) of radium-226 measured at each sediment sampling station in Lake Michigan

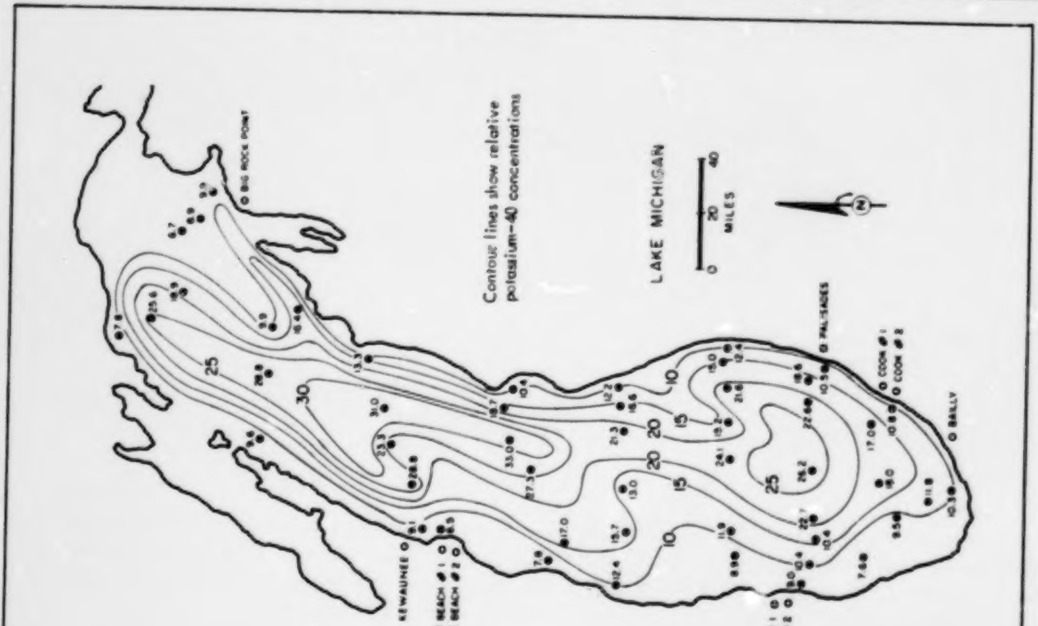
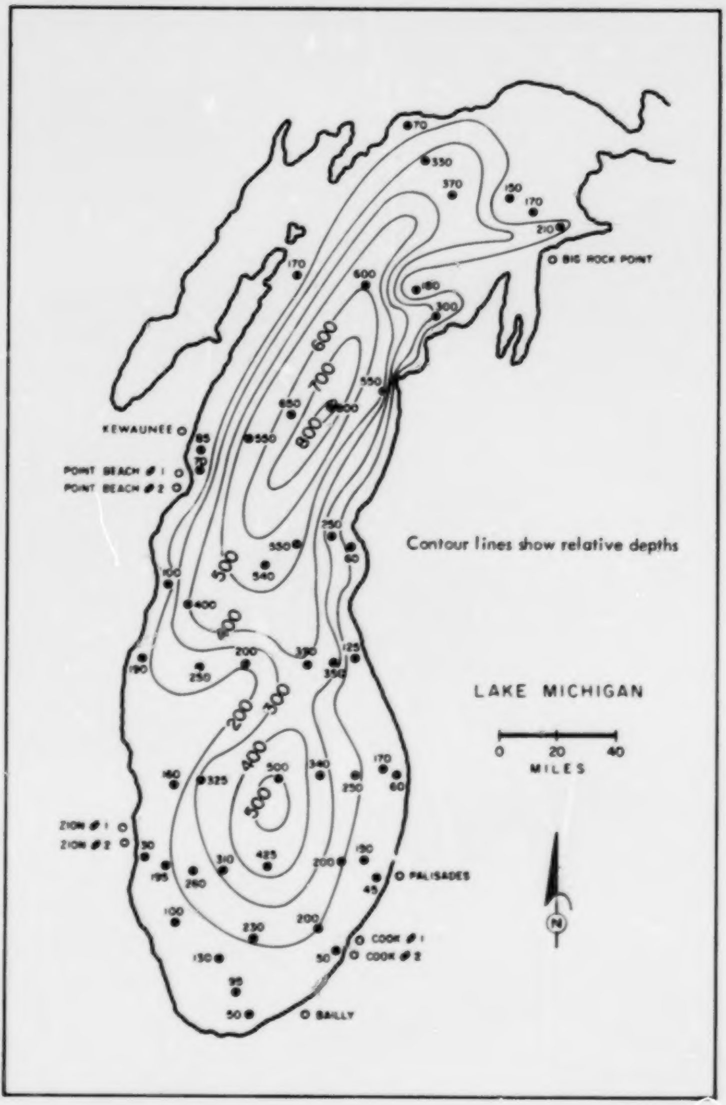

Contour lines show relative potassium-40 concentrations
LAKE MICHIGAN
0 20 40
MILES
N
BIG ROCK POINT
KEWAUNEE
POINT BEACH #1
POINT BEACH #2
ZION #1
ZION #2
PALISADES
COOK #1
COOK #2
BAILLY
10
15
20
25
30

Figure 4. Average concentrations (pCi/g) of potassium-40 measured at each sediment sampling station in Lake Michigan



Contour lines show relative depths
LAKE MICHIGAN
0
20
40
MILES
N
BIG ROCK POINT
KEWAUNEE
POINT BEACH # 1
POINT BEACH # 2
ZION # 1
ZION # 2
PALISADES
COOK # 1
COOK # 2
BAILLY
800
700
600
500
400
300
200
500
400
300
200
70
350
370
150
170
210
170
600
180
300
550
650
800
550
85
70
250
550
60
540
100
400
190
250
200
350
350
125
160
325
500
340
250
170
60
30
195
260
310
425
200
150
45
100
230
200
150
50
95
50

Figure 6. Average depth (feet) at each sediment sampling station in Lake Michigan

heavily industrialized area which discharges large amounts of suspended solids into the lake, is shown in figure 3. It is evident from figure 3 that a correlation exists between the concentration of cesium-137 in bottom sediments, the water current patterns, and the discharge of suspended solids into Lake Michigan.

Average concentrations of potassium-40 and radium-226 are shown in figure 4 and figure 5, respectively, for each of the 50 sediment sampling stations. Contour lines indicate areas of relatively high and low concentrations of the two radionuclides. Figure 6 shows the average water depth at each of the 50 sediment sampling stations and contour lines representing relative depths of Lake Michigan.

Visual observations were made on each sample to determine the type of sediment present: clay, silt, sand, or gravel. Figure 7 shows that sediments around the periphery of the lake are predominantly sand; sediments in the middle of the lake are predominantly clay.

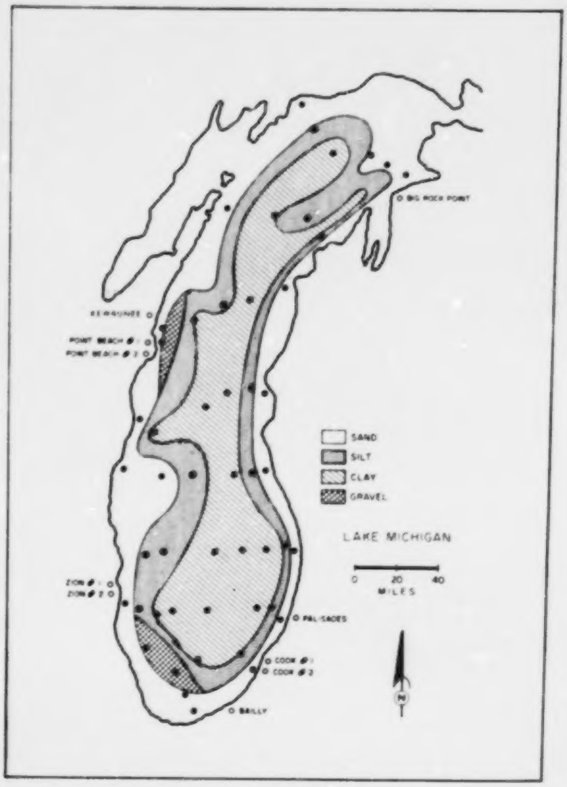


Figure 7. Types of bottom sediment found in Lake Michigan

Conclusion

Clay is the chemically active fraction of sediment and incorporates a variety of elements in its crystalline structure including silicon, aluminum, magnesium, calcium, potassium, and sodium (*5*). It is reasonable to assume that sediments having a high clay content will have a high content of potassium and radium, the latter being chemically similar to magnesium. A comparison of figures 4 and 5 with figure 7 shows this assumption to be valid.

Cesium-137 from fallout enters Lake Michigan uniformly in precipitation and runoff from the surrounding watershed. However, solids enter the lake nonuniformly; the heaviest loading comes from the Waukegan-Chicago-Gary area at the southern end of the lake. A likely explanation for the cesium-137 accumulation patterns in the bottom sediments is that much of the cesium-137 that enters the lake is adsorbed on particles that follow water current patterns and eventually settle to the bottom.

Fallout cesium-137 is a waste product that has entered Lake Michigan over a long period of time and at low levels. The present accumulation patterns of cesium-137 in the sediments of Lake Michigan may indicate future accumulation patterns of other waste products released into the lake under similar conditions.

Acknowledgements

The author wishes to acknowledge his gratitude to Dr. John C. Ayers, Professor of Oceanography, University of Michigan, for his guidance in the design and execution of this project, to Dr. John C. Golden, Commonwealth Edison Company, for his assistance in processing and correlating the data, while a graduate student at The University of Michigan, and to Dr. G. Hoyt Whipple, Professor of Radiological Health, University of Michigan, for his analytical review of the data obtained and conclusions reached.

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(*1*) GOLDEN, J. C., PLATO, P. A., and WHIPPLE, G. H. Lake Michigan Environmental Survey, Chapter A, Special Report No. 49. Great Lakes Research Division, University of Michigan, Ann Arbor (November 1970).

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(*3*) GUSTAFSON, P. F. and MILLER, J. E. The significance of Cs-137 in man and his diet. Health Phys 16:167-184 (1969).

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(5) BAVER, L. D. Soil physics. John Wiley and Sons, New York, N.Y. (1965) p. 19.

Radioactivity Levels in Selected Ohio Streams; the Great Miami River, the Little Miami River, and Mill Creek; June-August 1968

Office of Water Programs
U.S. Environmental Protection Agency[1]

A water quality study of the Little Miami River, Great Miami River, and Mill Creek was conducted by the Office of Water Programs, U.S. Environmental Protection Agency. Analyses were performed for uranium, radium-226, lead-210, thorium and strontium-90. Uranium concentrations in the Little Miami River, Great Miami River, and Mill Creek averaged 0.4, 0.9, and 0.3 μg/liter, respectively. Radium-226 concentrations averaged 0.08, 0.11, and 0.04 pCi/liter, respectively. Strontium-90 concentrations averaged 0.7, 0.4, and 1.1 pCi/liter, respectively. The average thorium concentration was less than 3 μg/liter in all three streams. Lead-210 averaged less than 0.2 pCi/liter in the Little and Great Miami Rivers and 0.7 pCi/liter in Mill Creek.

As part of the comprehensive water quality study of the Little Miami River (*1*), Great Miami River (*2*), and Mill Creek (*3*), the levels of radioactivity in dissolved solids in these streams and their tributaries were determined. Radiological measurements include the quantitative identification of several natural radionuclides—uranium, radium-226, lead-210, and thorium—and the fission product, strontium-90. Although the selected list of naturally-occurring radionuclides is not all-inclusive, their combined concentrations provide a reasonable estimate of the background level. Strontium-90 was selected as the measure of residual radioactivity attributable to atmospheric fallout from weapons testing. Radiological water quality, often overlooked, is important to an overall evaluation of present and future potential utilization of a water source.

The sampling program was comprised of 2-week sampling periods with the following time schedule:

Survey area	Sampling period (1968)
Mill Creek	August 5-16
Little Miami River	June 24-28 and July 8-12
Great Miami River	
Stations 1-20	July 15-26
Stations 21-35, excluding Station 34	August 5-16
Stations 34 and 36-54	June 24-28 and July 8-12

For each station, radioactivity analyses were performed on a composite sample prepared from four daily surface grab samples (collected twice weekly). Each analysis was performed on a 1 liter aliquot of the composite sample. Figure 1 shows the study area and the general locations of the sampling stations.

Four nuclear installations are located within the bounds of the study area:

Feed Materials Production Center (FMPC) near Fernald
Mound Laboratory at Miamisburg
Wright Patterson Air Force Base at Fairborn
General Electric Company at Evendale.

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[1] Engineering and Sciences Branch, Division of Applied Technology, Pollution Source Control Program, Office of Water Programs, U.S. Environmental Protection Agency, Cincinnati, Ohio.

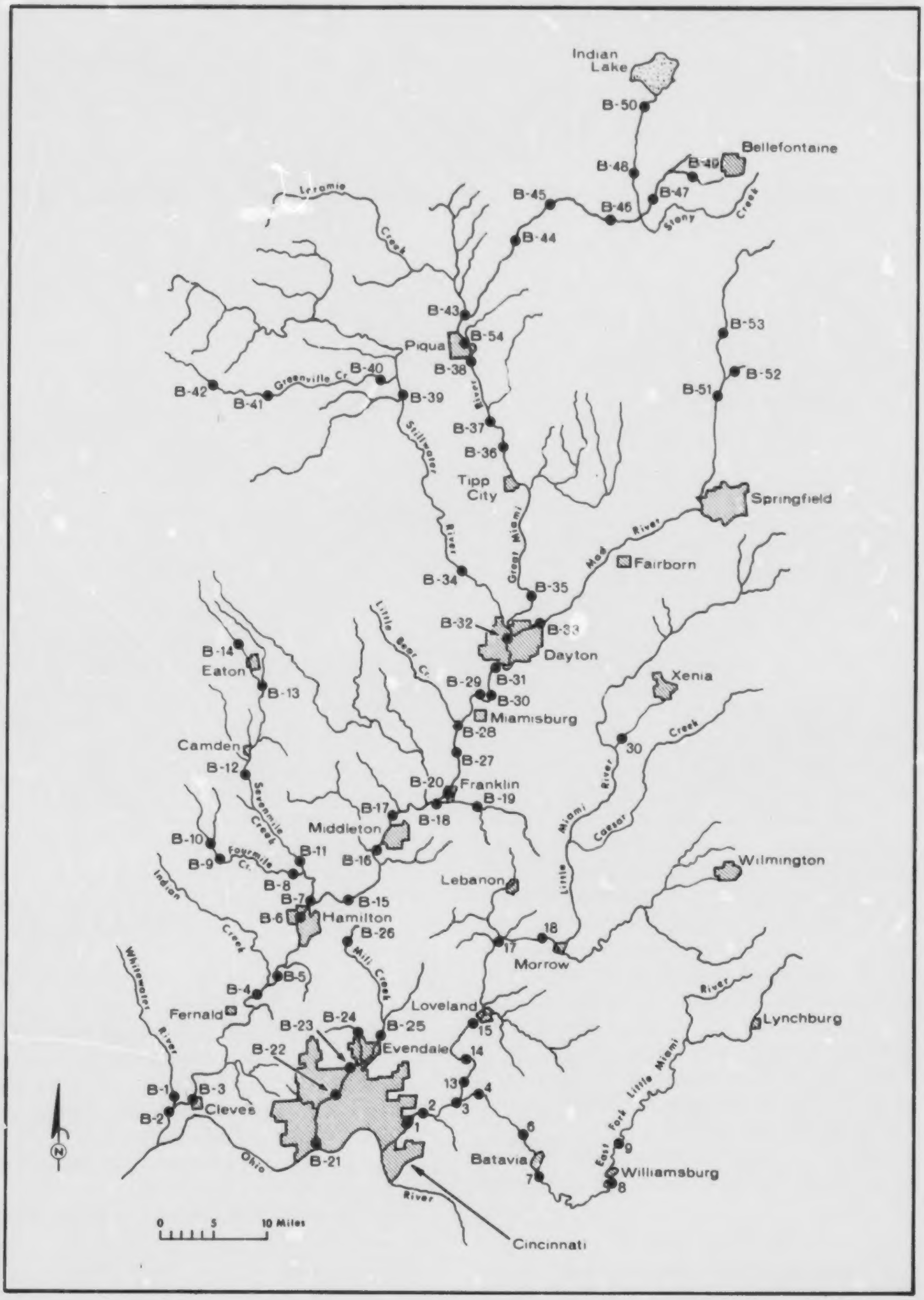
Indian Lake
B-50
Bellefontaine
B-48
B-49
B-45
B-47
B-46
Stony Creek
Loramie Creek
B-44
B-43
B-53
Piqua
B-54
B-38
B-52
B-51
B-40
Greenville Cr.
B-42
B-41
B-39
Stillwater River
Great Miami River
B-37
B-36
Tipp City
Springfield
Mad River
Fairborn
B-34
B-35
B-32
B-33
Little Bear Cr.
Dayton
B-14
Eaton
B-31
B-29
B-30
Xenia
B-13
Miamisburg
Camden
B-28
30
Caesar Creek
B-12
B-27
B-20
Franklin
B-19
Sevenmile Creek
B-17
B-18
Middleton
Little Miami River
B-10
Fourmile Cr.
B-11
Wilmington
B-9
B-16
Indian Creek
B-8
Lebanon
B-7
B-15
B-6
Hamilton
B-26
Mill Creek
18
17
Morrow
Whitewater River
B-5
B-4
Fernald
Loveland
B-23
B-24
B-25
15
Lynchburg
B-22
Evendale
14
East Fork Little Miami River
B-1
B-3
13
4
B-2
Cleves
2
3
1
6
N
Ohio River
B-21
9
Batavia
7
Williamsburg
8
0
5
10 Miles
Cincinnati

Figure 1. Study area and the general locations of sampling stations

Mound Laboratory and the FMPC routinely discharge liquid radioactive wastes into the Great Miami River. During the development of the aircraft nuclear propulsion project. General Electric used Mill Creek for the disposal of liquid radioactive wastes. However, the status of the General Electric facility since the termination of this project is not known. The one known potential source of liquid radioactive wastes at Wright Patterson Air Force Base is a small reactor facility used for research purposes. Although the manner of disposing of the reactor wastes was not established, the radioactivity level and volume of such wastes would be expected to be quite small in magnitude. Brief descriptions of Mound Laboratory and the FMPC are presented in table 1.

Results

Radionuclide concentrations are summarized in tables 2 and 3. In these tables the format for listing the stations was based on mileage from the stream mouth with the most upstream station listed first. The specific geographical location of each station is shown in figure 1.

The average concentrations of uranium, radium-226, and strontium-90 in the main stem streams are summarized in table 4. In all cases, the average thorium concentration was less than 3 μg/liter. Lead-210 concentrations averaged less than 0.2 pCi/liter in the Little and Great Miami Rivers, with a maximum value of 3.5 pCi/liter at Station B-3 on the Great Miami. The average lead-210 concentration in Mill Creek was 0.7 pCi/liter.

Table 1. Atomic Energy Commission Installations—Great Miami River

Facility and location	Operator	Activity	Prominent radionuclides in radioactive waste
Mound Laboratory Miamisburg, Ohio.	Monsanto Research Corporation.	Polonium and plutonium operations.	Tritium, polonium-210, and plutonium-238.
Feed Materials Production Center.	National Lead Company.	Processing high-grade uranium ores and ore concentrates to produce metallic uranium; and fabrication of the metal into fuel elements. Some thorium processing.	Uranium and radium-228.

Table 2. Dissolved radioactivity in the Little Miami River and Mill Creek[a]

Station number	Location	Uranium[b] (μg/liter)	Radium-226[c] (pCi/liter)	Lead-210[d] (pCi/liter)	Strontium-90[e] (pCi/liter)
	Little Miami River:				
30	Tributary, Glady Run upstream from Spring Valley on county road 144 bridge	0.6	0.03	<0.2	0.4
18	Downstream from Morrow, off U.S. 22 and Ohio 3, at Stubbs Road bridge	.4	.09	<.2	.4
17	Ohio 48 bridge downstream from South Lebanon	.3	.02	<.2	.3
15	Downstream from Loveland at Branch Hill, Guinea Pike bridge	.6	.08	<.2	.4
14	U.S. 50 Bypass and Ohio 126 near Miamiville	.6	.04	<.2	.7
13	Milford bridge at U.S. 50	<.1	.11	<.2	.3
3	Roundbottom Road across from Terrace Park, downstream from the confluence with the East Fork	.1	.09	<.2	.4
2	Newton Road bridge	.5	.15	.4	.8
1	Beechmont bridge	.1	.16	.5	.5
	Little Miami River (East fork):				
9	Upstream from Williamsburg on county road 80 bridge	.6	.05	.6	1.5
8	Downstream from Williamsburg on county road 131 near Ohio 32	.1	.07	—	.3
7	Upstream from Batavia at Ohio 222 bridge	.4	.06	<.2	1.7
6	Downstream from Batavia on Ohio 222	.5	.02	<.2	1.3
4	South Milford at country road 113 bridge	.3	.07	<.2	.8
	Mill Creek:				
B-26	Hamilton-Mason Road bridge	.3	.07	.6	1.2
B-25	U.S. 50 Bypass and Ohio 126 bridge	.2	.05	.5	1.1
B-24	West Fork; Ohio 4, Springfield Pike bridge	.2	.02	.8	1.3
B-23	Ohio 4, Springfield Pike bridge	.3	.01	.9	.7
B-22	Mitchell Avenue bridge	.3	.06	.3	1.0
B-21	Gest Street, Ohio 264	.2	<.01	.8	1.0

[a] Thorium concentrations were <3 μg/liter at all stations except station 9, 3 μg/liter and station 8, 4 μg/liter on the East Fork of the Little Miami River. Analysis performed by the methods in reference (*10*).
[b] Analysis performed by the methods in references (*5,6*).
[c] Analysis performed by the methods in reefrence (*7*).
[d] Analysis performed by the methods in reference (*8*).
[e] Analysis performed by the methods in reference (*9*).

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Table 3. Dissolved radioactivity in the Great Miami River and tributary streams[a]

Station number	Location	Distance from mouth of river (miles)	Uranium (μg/liter)	Radium-226 (pCi/liter)	Lead-210 (pCi/liter)	Strontium-90 (pCi/liter)
	Great Miami River:					
B-50	Headwater; Ohio 69 bridge	154.2	1.7	0.19	<0.2	0.9
B-48	County road T-21 near Logansville	147.1	1.3	.06	<.2	.7
B-46	Ohio 69 bridge	140.9	1.3	.21	<.2	.5
B-45	Pasco Road bridge	132.8	1.7	.16	<.2	.5
B-44	Ohio 706 bridge	128.2	.1	.01	<.2	.4
B-43	Piqua Road bridge	119.1	1.7	.11	<.2	.5
B-38	Farrington-Peterson Road bridge	111.6	.9	.13	<.2	<.2
B-37	Troy-Sidney Road bridge	106.6	.6	.10	<.2	.3
B-36	Ohio 41 bridge	105.1	1.0	.08	<.2	.8
B-35	Needmore Road bridge	87.1	1.0	.14	<.2	.5
B-32	South Dayton; U.S. 35	79.8	.4	.20	.4	.5
B-31	Bridge at Moraine, Springboro Pike	77.5	.5	.11	<.2	.4
B-30	Bridge at Dryer, Sellers Road	73.8	.6	.13	<.2	.6
B-29	Carrolton Pike bridge	69.8	.6	.09	.3	.5
B-28	Miamisburg Road bridge	67.3	.8	.12	<.2	.4
B-27	Chautauqua Road bridge	64.7	.3	.22	<.2	.4
B-20	Ohio 123 bridge	60.6	.8	.12	1.2	.4
B-17	Ohio 4 bridge	55.1	.7	.06	<.2	.3
B-16	Ohio 73 bridge	49.4	.9	.06	<.2	.3
B-15	Woodsdale Road bridge (Liberty-Fairfield Road)	43.4	.5	.07	.6	.4
B-6	Ohio 129 bridge in Hamilton	35.3	.8	.03	<.2	.3
B-5	Ohio 128 near Hamilton	32.2	1.1	.05	2.3	.4
B-4	U.S. 50 Bypass and Ohio 126 bridge	25.6	.2	.05	1.1	.2
B-3	U.S. 50 bridge; Cleves	7.8	1.1	.10	3.5	.5
B-2	Elizabeth Town bridge	4.7	.8	.11	.2	.3
	Bokengehalas Creek:					
B-47	County Road T-43 bridge		1.4	.15	<.2	.4
	Bluejacket Creek (Tributary to Bokengehalas Creek):					
B-49	County Road T-31 bridge		1.4	.10	<.2	.4
	Stillwater River:					
B-54	Klinger Road bridge		1.2	.11	1.3	.6
B-39	Falknor Road bridge at Ohio 48		.7	.10	.2	<.2
B-34	Heathcliff Road bridge		1.1	.10	<.2	.3
	Greenville Creek (Tributary to Stillwater River):					
B-42	Daly Road bridge		.3	.08	<.2	<.2
B-41	U.S. 36 bridge		.8	.09	—	<.2
B-40	Gettysburg Road bridge		1.6	.10	<.2	<.2
	Mad River:					
B-53	Ohio 29 bridge		1.4	.15	1.3	<.2
B-51	Ohio 55 bridge		1.1	.14	.4	<.2
B-33	Harshman Road bridge		.6	.19	<.2	.3
	Dugan Run (Tributary to Mad River):					
B-52	County Road 104		1.6	.14	<.2	<.2
	Clear Creek:					
B-19	Ohio 123 bridge		1.1	.15	.3	.5
B-18	Downstream from Franklin sewage treatment plant		.4	.03	.1	.5
	Fourmile Creek:					
B-10	Upstream from Oxford: Ohio 732 bridge		.8	.09	—	.7
B-9	Downstream from Oxford; County Road T-237 bridge		.4	<.01	<.2	.6
B-8	Eaton Road bridge at Warwick Road		1.2	.02	<.2	.6
B-7	At New Miami		.4	.09	<.2	.4
	Sevenmile Creek (Tributary to Fourmile Creek):					
B-14	Washington-Jackson Road bridge		.2	.08	<.2	.3
B-13	U.S. 127 bridge		.7	.09	—	.6
B-12	Downstream from Camden; County Road T-208		.7	.17	—	.6
B-11	U.S. 127 bridge		.8	.06	—	.5
	Whitewater River:					
B-1	Near Elizabeth Town		.7	.10	—	.5

[a] Thorium concentrations were <3 μg/liter at all stations.

Table 4. Average concentrations of uranium, radium-226, and strontium-90 in selected Ohio streams

Location	Uranium (μg/liter)	Radium-226 (pCi/liter)	Strontium-90 (pCi/liter)
Mill Creek	0.3	0.04	1.1
Little Miami River	.4	.08	.7
Great Miami River	.9	.11	.4

Uranium activity ratios (uranium-234/uranium-238) could not be determined for the individual stations because of the low uranium concentrations and small sample volumes. However, for a composite prepared from all the Great Miami River samples, an activity ratio (AR) of 1.24 ± 0.04 was determined. The

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excess of uranium-234 is consistent with the findings for freshwater streams (*4*). The activity ratio can be used to convert the mass concentration to an activity concentration by the application of the following relationship:

$$(0.334)\ (\text{uranium concentration, } \mu\text{g/liter})\ (1 + \text{AR}) = \text{uranium concentration, pCi/liter}$$

Therefore, for the average mass concentration of 0.9 μg/liter and the AR of 1.24, the average uranium concentration in the Great Miami River, in terms of activity, was less than 1 pCi/liter.

Discussion of results

The concentrations of the naturally-occurring radionuclides (uranium, radium-226, lead-210, and thorium) in the Little Miami River, Great Miami River, and Mill Creek were at low levels. Although there were some differences in the average radionuclide concentrations for the respective streams, these differences were too small to be of practical significance. Similarly, concentration variations in each stream (tables 2 and 3) were typical and consistent with a low background condition.

The batch discharge of liquid wastes from the Feed Materials Production Center to the Great Miami River did not produce any detectable increase in the uranium concentrations at the downstream stations (B-2 and B-3) during the study period. However, the possibility that a more prolonged sampling period might have shown an increase is suggested by the findings of the water monitoring program conducted by the facility contractor, the National Lead Company. For 1967, weekly water sample analyses of the National Lead Company showed an average increase of 5 μg/liter in the uranium concentration of the river as the result of waste releases—9 μg/liter upstream from the FMPC and 14 μg/liter downstream (*11*). The fact that these concentrations are nearly one order of magnitude greater than the 1968 concentrations reported herein is judged to be attributable to differences in the sensitivities of the uranium methods employed by the respective laboratories, not seasonal variations. Liquid waste releases also increased the radium-228 concentration in the river by an estimated 0.3 pCi/liter during 1967 (*11*). (Radium- 228 analyses were not conducted since the presence and prominence of this radionuclide in the FMPC effluent were not known at the time of the field study.)

No attempt was made to quantitate changes in radiological water quality attributable to liquid wastes from the Mound Laboratory. Such changes would be manifest in increased concentrations of tritium, polonium-210, and plutonium-238. However, according to the semiannual reports on the environmental levels of radioactivity in the vicinity of the laboratory, sufficient dilution is available in the Great Miami River to dilute the waste concentrations of radionuclides to levels which are indistinguishable from background levels (*12,13*). For example, during 1967, the reported average concentrations of tritium, polonium, and plutonium at the Chautauqua Road Bridge (station B-27) did not differ from the corresponding upstream or background concentrations. The Chautauqua Road Bridge station is about 1.5 miles below the point of discharge of liquid polonium wastes and about 0.5 miles below the drainage ditch carrying treated tritium and plutonium wastes to the river.

Considering the possibility that the General Electric Company discharges liquid radioactive wastes containing activiation and fission products to Mill Creek, qualitative gamma-ray analyses were performed on the samples from Stations B-23 and B-25, downstream and upstream from the plant site, respectively. Comparison of the gamma spectra and strontium-90 data for both stations did not indicate the presence of a waste source. Although this is not unequivocal support for a conclusion that General Electric does not discharge liquid radioactive wastes to Mill Creek, the negative finding does show that, if liquid discharges are being made, the resultant concentrations are at low levels.

Strontium-90 concentrations were at relatively low levels and in general agreement with the most recently reported monitoring data of the FWPCA, Division of Pollution Surveillance (*14*). During the second and third quarters of 1967, the average strontium-90 concentration in United States surface waters was about 2 pCi/liter. This average exceeds the specific results of the field study in all cases. On a more localized scale, 1967 second quarter averages for the Little Miami River and the Ohio River at Cincinnati, Ohio, were 1.3 and 1.2 pCi/liter, respectively. Correspondingly, the field study yielded a concentration of only 0.5 pCi/liter for the Little Miami at Cincinnati (station 1). In the absence of atmospheric testing of weapons or other sources of strontium-90, the radiostrontium concentration will decline with time. Although such a trend will be evident over a long period of time (years), the short term variations can be expected to be large since many factors influence the stream concentration (compositing period and procedure, stream flow, etc.). The absolute difference in the 1967 and 1968 results for the Little Miami River is considered to be a short term variation rather than an absolute decrease.

Summarizing, the concentrations of natural radionuclides and strontium-90 in the Great Miami River and Little Miami River were well below the concentration limits for drinking water. All separate radium-226 and strontium-90 concentrations were within the limits of "desirable" criteria recommended by the National Technical Advisory Committee for surface waters used for public water supplies (table 5) (*15*). Uranium concentrations in these rivers closely approached the recommended "desirable" level. Further, the use of the Great Miami River for the ultimate disposal of liquid radioactive wastes from two nuclear installations has not produced any changes in radiological water quality which are of public health significance.

Table 5. Recommended surface water criteria for public water supplies, National Technical Advisory Committee

Constituent	Permissible criteria[a]	Desirable criteria[b]
Uranium	4.4 mg/liter	[c]Absent
Radium-226	3 pCi/liter	<1 pCi/liter
Strontium-90	10 pCi/liter	<2 pCi/liter

[a] Concentrations in raw surface waters which allow the production of a safe, clear, potable, aesthetically pleasing, and acceptable public water supply which meets the limits of the Public Health Service Drinking Water Standards.

[b] Concentrations in raw surface waters which represent high-quality water in all respects for use as public water supplies.

[c] Not detectable by the most sensitive analytical procedure in "Standard Methods" or other approved procedure.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, December 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

> Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations
>
> Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

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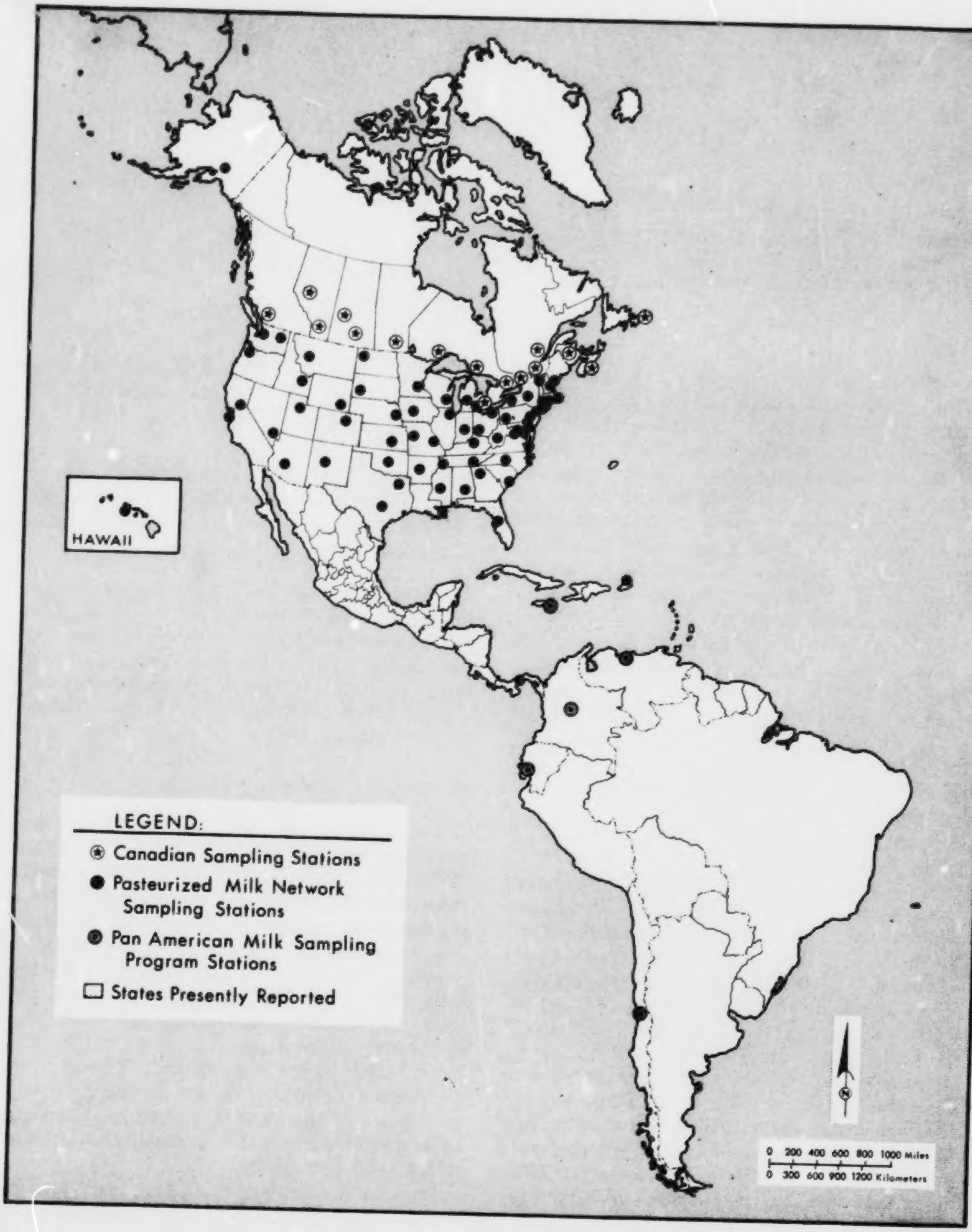
HAWAII
LEGEND:
® Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

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metabolically similar radionuclides (radiostrontium, and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the experiment.

The accuracy results of this experiment for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of all radionuclides from those of previous studies. Some improvement is still needed on the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration ±2σ	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Iodine-131 (69 ±6 pCi/liter)	13 (100%)	0	0	13
Cesium-137 (52 ±6 pCi/liter)	12 (92%)	1 (8%)	0	13
Strontium-89 (31 ±6 pCi/liter)	9 (90%)	1 (10%)	0	10
Strontium-90 (41.6 ±2.4 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 shows whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the large value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≧50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≧20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≧100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was pre-

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Table 2. Concentrations of radionuclides in milk for December 1971 and 12-month period, January 1971 through December 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	6	13	12
Alaska:	Palmer[c]	P	6	4	12	14
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	10	12	14	14
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	3	0	0
	Del Norte	P	9	13	16	11
	Fresno	P	0	2	6	3
	Humboldt	P	4	4	13	5
	Los Angeles	P	2	2	9	2
	Mendocino	P	3	6	10	8
	Sacramento	P	2	3	0	3
	San Diego	P	0	1	6	3
	Santa Clara	P	2	2	7	4
	Shasta	P	3	3	8	6
	Sonoma	P	2	3	9	6
Colo:	Denver[c]	P	NA	5	15	8
	East	R	(d)		[e]0	[e]0
	Northeast	R	(d)		[e]0	1
	Northwest	R	(d)		NS	[e]0
	South central	R	(d)		NS	NS
	Southeast	R	(d)		NS	[e]0
	Southwest	R	(d)		[e]0	2
	West	R	(d)		NS	[e]0
Conn:	Hartford[c]	P	NA	7	0	8
	Central	P	7	7	14	14
Del:	Wilmington[c]	P	NA	8	0	5
D.C:	Washington[c]	P	NA	8	0	8
Fla:	Tampa[c]	P	5	5	49	43
	Central	R	6	7	39	54
	North	R	13	10	24	23
	Northeast	R	5	7	23	33
	Southeast	R	7	11	19	18
	Tampa Bay area	P	5	6	36	42
	West	R	4	6	44	42
Ga:	Atlanta[c]	P	NA	10	0	16
Hawaii:	Honolulu[c]	P	2	3	0	2
Idaho:	Idaho Falls[c]	P	0	5	0	4
Ill:	Chicago[c]	P	5	6	16	9
Ind:	Indianapolis[c]	P	NA	7	0	5
	Central	P	7	9	10	14
	Northeast	P	6	7	10	12
	Northwest	P	7	10	10	15
	Southeast	P	8	8	10	14
	Southwest	P	6	9	15	15
Iowa:	Des Moines[c]	P	NA	5	0	3
	Iowa City	P	5	7	0	13
	Des Moines	P	5 (3)	7	11	12
	Little Cedar	P	7	3	11	13
	Spencer	P	4	6	12	11
Kans:	Wichita[c]	P	NA	7	0	2
	Coffeyville	P	7	9	8	15
	Dodge City	P	5	6	6	8
	Falls City, Nebr	R	NS	4	NS	12
	Hays	P	6	10	11	10
	Kansas City	P	7	9	12	15
	Topeka	P	7	8	7	10
	Wichita	P	5	10	13	11
Ky:	Louisville[c]	P	NA	9	0	4
La:	New Orleans[c]	P	13	14	12	20
Maine:	Portland[c]	P	NA	9	12	19
Md:	Baltimore[c]	P	NA	8	11	7
Mass:	Boston[c]	P	6	8	0	13
Mich:	Detroit[c]	P	NA	7	0	10
	Grand Rapids[c]	P	NA	8	11	10
	Bay City	P	8 (2)	7	7 (2)	15
	Charlevoix	P	8 (3)	9	9 (4)	15
	Detroit	P	7	7	15	9
	Grand Rapids	P	10	7	0	11
	Lansing	P	10	8	7 (2)	15
	Marquette	P	4	9	24 (2)	23
	Monroe	P	0	4	0 (2)	4
	South Haven	P	6	6	0 (5)	9
Minn:	Minneapolis[c]	P	NA	8	12	14
	Bemidji	P	7	9	16	20
	Duluth	P	15	17	26	28
	Fergus Falls	P	9	8	21	14
	Little Falls	P	15	16	26	29
	Mankato	P	6	6	0	12
	Minneapolis	P	12	19	15	17

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for December 1971 and 12-month period, January 1971 through December 1971—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average[c]	Monthly average[b]	12-month average[c]
UNITED STATES—continued						
Minn:	Rochester	P	8	8	11	13
	Worthington	P	7	5	11	0
Miss:	Jackson[e]	P	NA	12	11	10
Mo:	Kansas City[e]	P	NA	8	13	7
	St. Louis[e]	P	NA	6	0	5
Mont:	Helena[e]	P	NA	6	0	10
Nebr:	Omaha[e]	P	NA	7	0	4
Nev:	Las Vegas[e]	P	NA	2	0	1
N.H:	Manchester[e]	P	NA	8	12	19
N.J:	Trenton[e]	P	NA	8	0	9
N. Mex:	Albuquerque[e]	P	NA	3	0	0
N.Y:	Buffalo[e]	P	5	7	11	10
	New York City[e]	P	NA	8	0	11
	Syracuse[e]	P	NA	7	0	8
	Albany	P	7	7	[d]0	[d]0
	Buffalo	P	NS		NS	
	Massena	P	[d]0	6	[d]0	[d]0
	New York City	P	7	7	[d]0	[d]0
	Syracuse	P	[d]0	4	NA	
N.C:	Charlotte[e]	P	NA	11	13	12
N. Dak:	Minot[e]	P	NA	9	15	13
Ohio:	Cincinnati[e]	P	NA	7	0	2
	Cleveland[e]	P	NA	7	0	6
Okla:	Oklahoma City[e]	P	NA	6	12	11
Oreg:	Portland[e]	P	3	5	0	6
	Baker	P	NA	3	[d]0	2
	Coos Bay	P	NA	4	[d]0	4
	Eugene	P	NA	2	17	3
	Medford	P	NA	2	[d]0	3
	Portland composite	P	NA	6	NA	6
	Portland local	P	NA	4	[d]0	8
	Redmond	P	NA	3	[d]0	2
	Tillamook	P	NA	5	[d]0	15
Pa:	Philadelphia[e]	P	NA	8	0	6
	Pittsburgh[e]	P	NA	11	0	9
	Dauphin	P	7	8	21	13
	Erie	P	24	9	31	18
	Philadelphia	P	3	7	0	16
	Pittsburgh	P	6	8	18	14
R.I:	Providence[e]	P	NA	8	11	16
S.C:	Charleston[e]	P	10	9	12	14
S. Dak:	Rapid City[e]	P	NA	6	13	6
Tenn:	Chattanooga[e]	P	NA	9	13	10
	Memphis[e]	P	NA	7	11	10
	Chattanooga	P	NA	8	12	15
	Clinton	P	NA	9	21	14
	Fayetteville	P	NA	9	0	9
	Kingston	P	NA	7	6 (2)	10
	Knoxville	P	NA	7	0	11
	Lawrenceburg	R	NA	5	11	4
	Nashville	P	NA	7	11	10
	Pulaski	R	NA	8	15	4
Tex:	Austin[e]	P	NA	1	0	0
	Dallas[e]	P	NA	6	0	4
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[e]	P	0	5	0	12
Vt:	Burlington[e]	P	NA	6	0	10
Va:	Norfolk[e]	P	NA	9	0	5
Wash:	Seattle[e]	P	NA	5	0	5
	Spokane[e]	P	NA	6	14	6
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	3	0	5
	Sandpoint, Idaho	R	8	12	22	22
	Skagit County	R	6	8	0	12
W. Va:	Charleston[e]	P	NA	7	11	8
Wisc:	Milwaukee[e]	P	NA	6	0	8
Wyo:	Laramie[e]	P	NA	4	13	2

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for December 1971 and 12-month period, January 1971 through December 1971—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:					
Alberta: Calgary	P	7	7	18	20
Edmonton	P	6	7	24	24
British Columbia:					
Vancouver	P	8	9	22	24
Manitoba:					
Winnipeg	P	6	7	19	22
New Brunswick:					
Fredericton	P	10	12	14	23
Newfoundland:					
St. John's	P	17	17	20	31
Nova Scotia:					
Halifax	P	9	11	14	23
Ontario: Ottawa	P	5	6	5	14
Sault St. Marie	P	11	14	28	33
Thunder Bay	P	11	12	25	25
Toronto	P	4	5	8	13
Windsor	P	4	5	13	11
Quebec: Montreal	P	7	7	19	19
Quebec	P	10	10	25	30
Saskatchewan:					
Regina	P	7	7	22	16
Saskatoon	P	8	9	16	18
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal[c]	P	NA	1	0	7
Chile: Santiago	P	0	0	0	2
Colombia:					
Bogota	P	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Montego Bay	P	NS	5	NS	80
Puerto Rico:					
San Juan[c]	P	NA	4	0	12
Venezuela:					
Caracas	P	0	0	0	0
PMN network average[f]		6	7	6	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131:		Cesium-137:		Strontium-90:
	Colorado—25 pCi/liter		Colorado—25 pCi/liter	New York—3 pCi/liter
	Michigan—14 pCi/liter		New York—20 pCi/liter	
	Oregon—15 pCi/liter		Oregon—15 pCi/liter	

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

sented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average

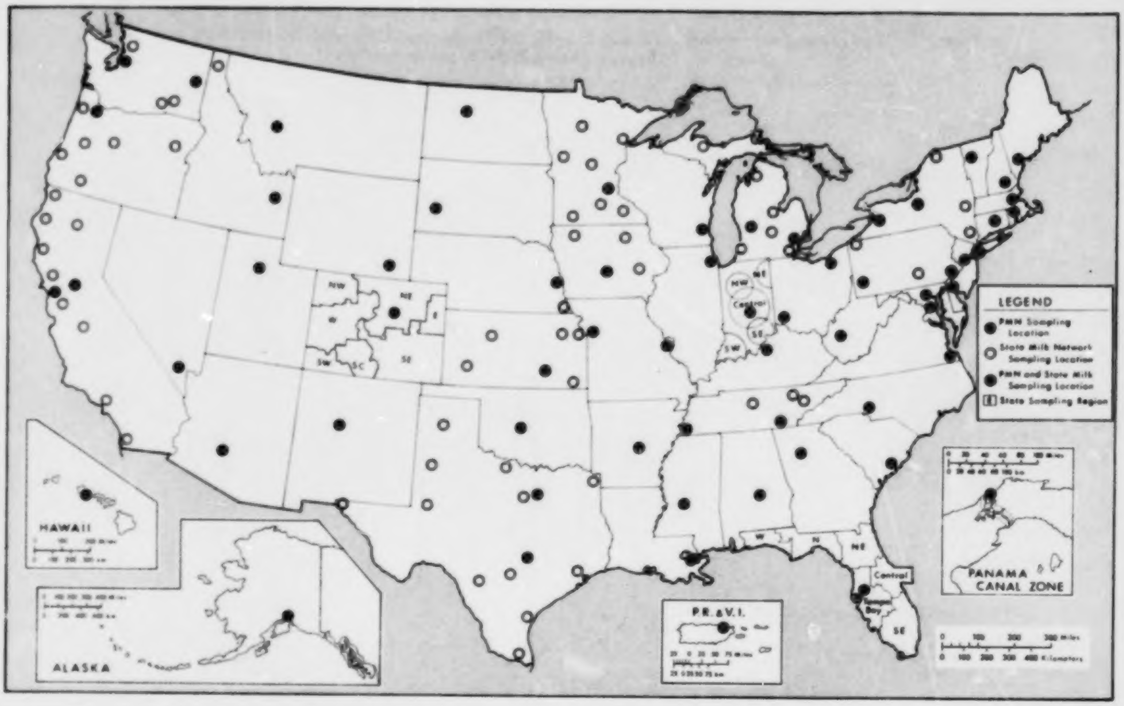

Figure 2. State and PMN milk sampling stations in the United States

for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for December 1971 and the 12-month period, January 1971 to December 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for December 1971 were below the respective practical reporting levels. The following station averages reflect samples in which strontium-89 was detected: Calif., Del Norte (State) 23 pCi/liter, Humboldt (State) 10 pCi/liter, Mendocino (State) 6 pCi/liter. Iodine-131 and barium-140 were not detected.

Strontium-90 monthly averages ranged from 0 to 24 pCi/liter in the United States for December 1971, and the highest 12-month average was 19 pCi/liter at Minneapolis, Minn. (State), representing 9.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 49 pCi/liter in the United States for December 1971, and the highest 12- month average was 54 pCi/liter (Central Florida), representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks.

Bureau of Radiological Health
Division of Environmental Sanitation
California State Deportment of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	January-June 1971	December 1971
Connecticut Standard Diet	January-December 1970	December 1971
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

Radiostrontium in Milk, January-December 1970

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring for strontium-90 in liquid whole milk to estimate the dietary contribution from the ingestion of the radionuclide from this source.

The New York City sample is a monthly composite of pasteurized milk purchased daily at retail stores. Five main dairies are represented in the sample. The powdered milk sampling at Perry, N.Y. was terminated at the end of 1969.

The strontium-90 to calcium ratios for New York City for January-December is presented in table 1.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-December 1969	June 1971

Table 1. Strontium-90 to calcium ratios in milk, January–December 1970

Sampling location	Strontium-90 to calcium ratio (pCi /g)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y (liquid whole milk)	8.2	7.0	6.7	7.4	10.0	11.6	11.0	8.5	7.9	7.4	7.2	7.5

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[1] Data summarized from "Fallout Program Quarterly Summary Report," HASL-246, January 1, 1972, available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Radionuclides in Institutional Diet Samples, July-September 1971

Environmental Protection Agency and Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present, 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1,2*). Extrapolating this infor-

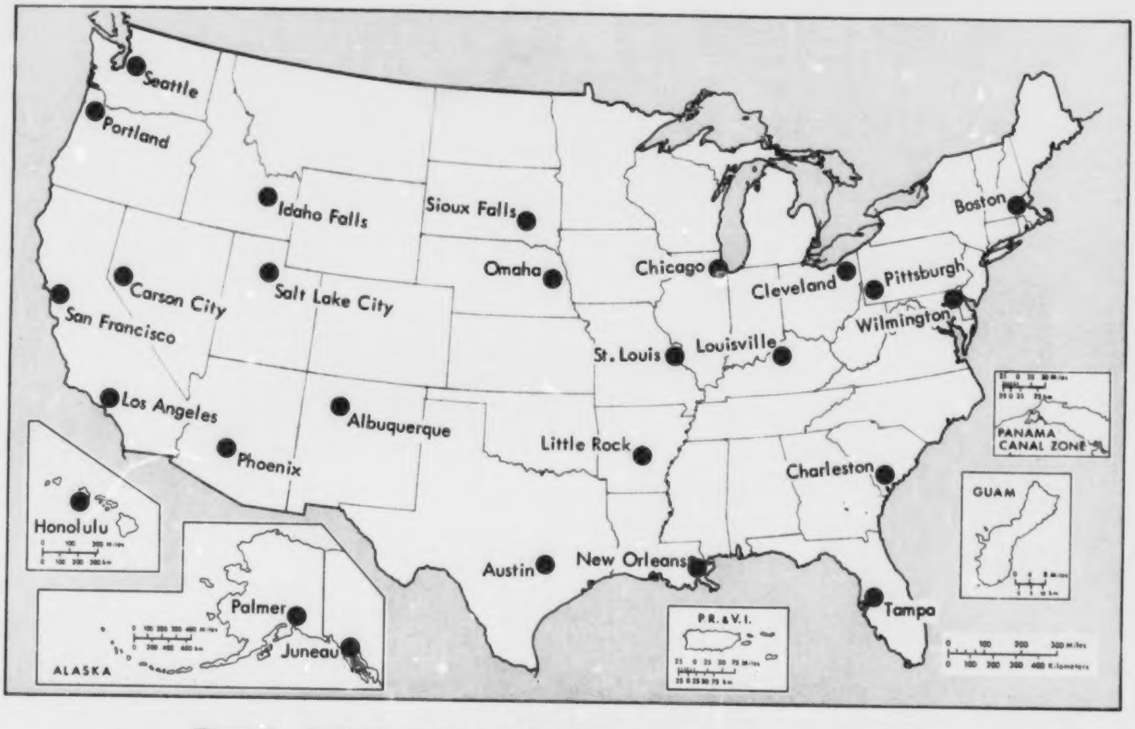
Seattle
Portland
Idaho Falls
Sioux Falls
Boston
Carson City
Salt Lake City
Omaha
Chicago
Cleveland
Pittsburgh
Wilmington
San Francisco
St. Louis
Louisville
Los Angeles
Albuquerque
Little Rock
Phoenix
Charleston
Honolulu
Austin
New Orleans
Palmer
Juneau
ALASKA
Tampa
P.R. & V.I.
GUAM
PANAMA CANAL ZONE
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Institutional diet sampling locations as of July–September 1971

2b

mation, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water —which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the Western Environmental Research Laboratory, Las Vegas, Nev.; the Eastern Environmental Radiation Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (*3*).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during July-September 1971. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.54 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1970.

Strontium-90 dietary intake averaged 7 pCi/day during this period. Cesium-137 intake averaged 11 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Barium-140 and iodine-131

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children, July–September 1971

Location of Institution		Month[a] (1971)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	July	1.18	0.7	0.8	1.8	2.1	7	8	19	22
	Palmer	July	1.58	.4	.7	1.3	2.1	5	8	0	0
Ariz:	Phoenix	Sept	1.90	.5	.9	1.1	2.2	0	0	0	0
Ark:	Little Rock	July	1.31	.6	.7	1.8	2.3	8	10	11	14
Calif:	Los Angeles	July[b]	1.83	.3	.6	1.2	2.3	0	0	0	0
	San Francisco	July	1.96	.8	1.5	1.5	3.0	3	7	0	0
Del:	Wilmington	July	2.17	.6	1.4	1.1	2.5	6	14	19	41
Fla:	Tampa	Aug	1.86	.5	.9	1.3	2.4	4	7	19	35
Hawaii:	Honolulu	July	2.27	.5	1.1	1.3	3.1	0	0	11	25
Idaho:	Idaho Falls	July[b]	2.57	.8	2.0	1.7	4.5	6	15	20	51
Ill:	Chicago	July	1.44	.7	1.0	1.7	2.4	5	7	0	0
Ky:	Louisville	July	2.36	.7	1.7	1.6	3.7	7	17	0	0
La:	New Orleans	July[b]	1.97	.6	1.2	1.5	3.0	10	19	14	28
Mass:	Boston	July	1.91	.5	.9	0.9	1.8	6	11	0	0
Mo:	St. Louis	July	1.24	.8	1.0	1.1	1.4	6	7	0	0
Nebr:	Omaha	July[b]	2.11	.8	1.6	1.8	3.8	6	13	0	0
Nev:	Carson City	July	1.64	.7	1.1	1.3	2.2	0	0	0	0
N. Mex:	Albuquerque	NS									
Ohio:	Cleveland	July	1.24	.7	.9	1.3	1.7	8	10	14	17
Oreg:	Portland	July[b]	1.90	.6	1.1	1.6	3.1	3	6	0	0
Pa:	Pittsburgh	July	2.45	.4	1.1	1.1	2.7	5	12	0	0
S.C:	Charleston	July	1.10	.8	.9	1.3	1.4	7	7	18	20
S. Dak:	Sioux Falls	July[b]	1.26	.9	1.1	1.3	1.6	7	8	0	0
Tex:	Austin	July[b]	1.55	.8	1.2	1.4	2.1	0	0	0	0
Utah:	Salt Lake City	July[b]	2.31	.5	1.1	1.3	3.0	0	0	16	37
Wash:	Seattle	July[b]	2.33	.5	1.3	1.5	3.5	0	0	0	0
Institutional average			1.82	0.6	1.1	1.4	2.6	4	7	6	12
ADDENDUM: January—March 1971											
Idaho:	Idaho Falls	Jan[b]	2.30	1.0	2.2	1.7	3.9	12	27	18	41

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131 and barium-140 were not detected at any station during this period. Seattle, Wash. had a strontium-89 concentration of 6 pCi/kg.
NS, no sample.

concentrations were below detectable levels. Strontium-89 was detected in Phoenix, Ariz.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140, 10 pCi/kg; cesium-137, 10 pCi/kg.

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(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-September 1970	February 1971
October-December 1970	May 1971
January-March 1971	September 1971
April-June 1971	November 1971

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1969	October 1971
Colorado River Basin	1968	March 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
New York	July 1969-June 1970	September 1971
Radioactivity in Florida Waters	1969	January 1972
Tritium in Community Water Supplies	1969	December 1970
Washington	July 1969-June 1970	March 1972

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(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

29

Gross Radioactivity in Surface Waters of the United States August 1971

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957, as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). This activity was reinitiated as a monthly report series with the publication of data for January 1971 (September 1971 issue). The unpublished data for the time interval, November 1968 through December 1970, will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 15 rivers during August 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition

Table 1. Gross radioactivity in U.S. surface waters, August 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
Animas River:									
Cedar Hills, N. Mex	1	2		2		8		13	
Bear River:									
Idaho	1	1		2		5		15	
Clinch River									
Kingston, Tenn	[a]3	<0.2	(<0.2—<0.2)	<1	(<0.2—1)	1	(1—2)	3	(1—5)
Colorado River:									
above Moab, Colo	[a]5	6	(1—17)	12	(4—21)	17	(8—41)	33	(13—49)
below Moab, Colo	[a]5	3	(1—8)	9	(7—12)	15	(5—31)	31	(19—52)
at Silt, Colo	1	<.1		4		3		10	
Dolores River:									
Bedrock, Colo	[a]3	7	(1—14)	30	(17—41)	27	(9—42)	80	(70—90)
Gateway, Colo	[a]4	1	(1—1)	22	(16—28)	10	(6—21)	90	(76—106)
Green River:									
Greendale, Utah	1	<.1		5		2		17	
Gunnison River:									
Grand Junction, Colo	1	4		12		19		55	
Mississippi River:									
Burlington, Iowa	1	1		1		5		10	
Ohio River:									
Cincinnati, Ohio	[a]4	<.2	(<.2—<.2)	<1	(<.2—1)	3	(2—4)	8	(7—9)
Roanoke River:									
John Kerr Dam, Va	[a]5	<1	(<.2—1)	<.2	(<.2—<.2)	3	(2—4)	5	(5—6)
San Miguel River:									
above Uravan, Colo	[a]4	<2	(<.2—2)	4	(2—6)	4	(3—7)	15	(14—16)
below Uravan, Colo	[a]4	2	(1—4)	13	(10—17)	7	(4—14)	40	(24—59)
at Naturita, Colo	[a]4	1	(<.2—2)	3	(2—6)	5	(1—11)	15	(12—19)
St Lawrence River:									
Massena, N.Y	[a]4	<.2	(<.2—<.2)	<1	(<.2—1)	3	(2—4)	6	(5—8)
Susquehanna River:									
Conowingo, Md	1	<.2		<.2		2		3	
White River:									
Watson, Utah	1	<.2		2		2		11	
Yampa River:									
Maybell, Colo	1	<.2		2		4		9	

[a] Where more than one sample is analyzed, the minimum and maximum values are in parentheses.

of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION, AMERICAN WATER WORKS ASSOCIATION, and WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Radiostrontium in Tap Water, January–June 1971

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137 to strontium-90 ratios in New York City tap water for January through June 1971 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

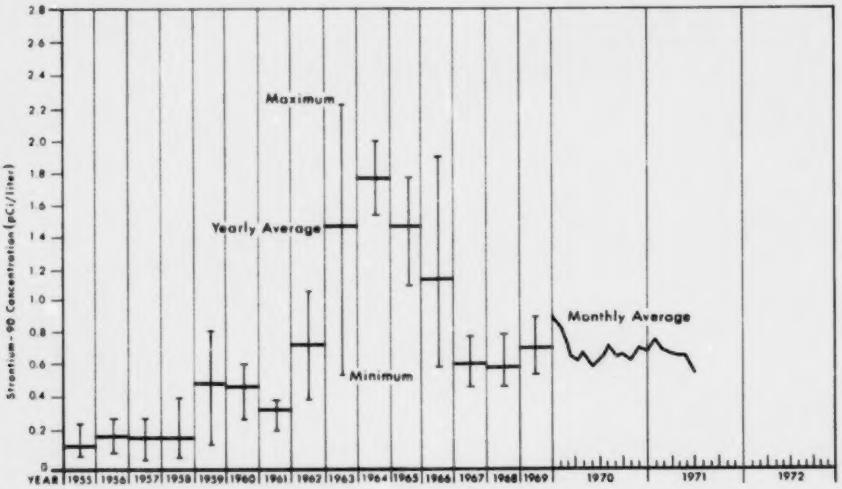

Figure 1. Strontium-90 concentrations in New York City tap water, 1955—June 1971

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL-246 (January 1, 1972). This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Radiostrontium in New York City tap water, January–June 1971

Sampling months	Strontium-90[a] (pCi/liter)	Cesium-137/strontium-90
January	0.75	0.09
February	.66	.09
March	.64	.10
April	.63	.11
May	.63	.13
June	.54	NA

[a] Approximately 100 liters per sample.
NA, no analysis.

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(2) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1970	October 1971

Tritium Surveillance System, July-September 1971

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for the period January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for July-December 1969, have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 quarterly drinking water samples at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and quarterly samples at 39 surface water stations (figure 2). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be

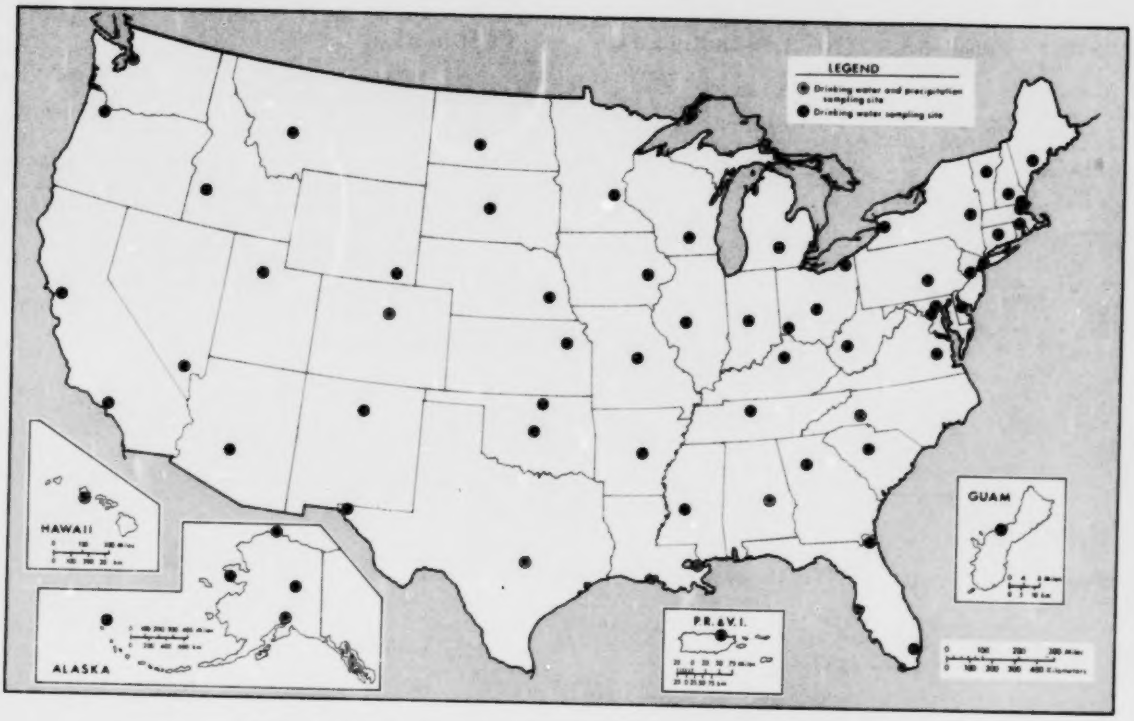
LEGEND
Drinking water and precipitation sampling site
Drinking water sampling site
HAWAII
ALASKA
P.R. & V.I.
GUAM

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

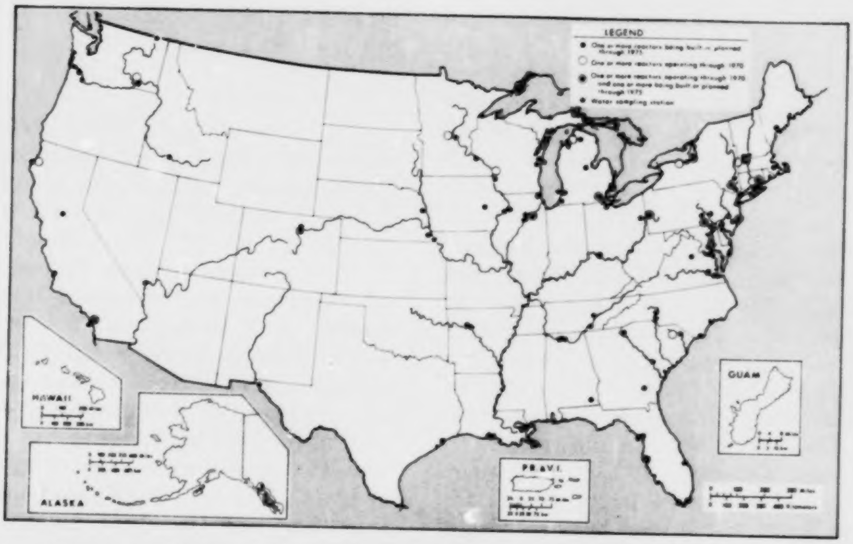
LEGEND
One or more reactors being built or planned through 1975
One or more reactors operating through 1970
One or more reactors operating through 1970 and one or more being built or planned through 1975
Water sampling station
HAWAII
ALASKA
PR & V.I.
GUAM

Figure 2. Surface water sampling locations for tritium surveillance system

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Table 1. Tritium concentration in tap water (RAN stations) July–September 1971

Location		Date collected	Tritium concentration (nCi/liter ±2σ)
Ala:	Montgomery	7/9	[a]0
Alaska:	Anchorage	7/2	0
	Attu Island	7/2	0
	Fairbanks	7/8	0
	Juneau	7/19	0
	Kodiak	7/1	0
	Nome	7/30	0.7 ± 0.4
	Point Barrow	NS	
Ariz:	Phoenix	7/1	0
Ark:	Little Rock	7/19	.3 ± .2
Calif:	Berkeley	7/1	0
	Los Angeles	7/1	0
C.Z:	Ancon	8/5	[a]0
Colo:	Denver	7/12	1.1 ± .4
Conn:	Hartford	7/15	0
Del:	Dover	7/12	0
D.C:	Washington	7/26	[a]0
Fla:	Jacksonville	7/6	[a]0
	Miami	7/7	[a]0
Ga:	Atlanta	7/2	.5 ± .2
Guam:	Agana	7/8	0
Hawaii:	Honolulu	7/1	0
Idaho:	Boise	7/9	0
Ill:	Springfield	7/19	.5 ± .4
Ind:	Indianapolis	8/6	0
Iowa:	Iowa City	7/2	.6 ± .4
Kans:	Topeka	7/8	0
Ky:	Frankfort	7/6	.4 ± .2
La:	New Orleans	7/6	.4 ± .2
Maine:	Augusta	7/8	0
Md:	Baltimore	7/6	[a]0
Mass:	Lawrence	7/8	0
	Winchester	7/12	0
Mich:	Lansing	7/12	0
Minn:	Minneapolis	7/6	.7 ± .4
Miss:	Jackson	7/2	.3 ± .2
Mo:	Jefferson City	7/1	0
Mont:	Helena	7/6	.7 ± .4
Nebr:	Lincoln	7/7	0
Nev:	Las Vegas	7/6	1.0 ± .4
N.H:	Concord	7/8	0
N.J:	Trenton	7/9	0
N. Mex:	Santa Fe	7/1	.5 ± .4
N.Y:	Albany	7/9	0
	Buffalo	7/12	0
	New York	9/9	0
N.C:	Gastonia	7/6	[a]0
N. Dak:	Bismarck	7/21	.7 ± .4
Ohio:	Cincinnati	7/13	.5 ± .4
	Columbus	7/14	.6 ± .4
	Painesville	8/4	.6 ± .4
Okla:	Oklahoma City	7/6	.4 ± .2
	Ponca City	7/6	[a]0
Oreg:	Portland	8/12	0
Pa:	Harrisburg	7/15	0
P.R:	San Juan	7/7	[a]0
R.I:	Providence	7/8	0
S.C:	Columbia	7/7	[a]0
S. Dak:	Pierre	7/1	1.4 ± .4
Tenn:	Nashville	7/6	.4 ± .2
Tex:	Austin	7/7	[a]0
	El Paso	7/8	[a]0
Utah:	Salt Lake City	7/8	0
Vt:	Barre	7/8	0
Va:	Richmond	7/12	[a]0
Wash:	Seattle	7/6	.4 ± .4
	Spokane	7/1	0
W. Va:	Charleston	7/6	.4 ± .2
Wisc:	Madison	7/15	1.5 ± .4
Wyo:	Cheyenne	7/6	1.2 ± .4
Average[b]			0.2

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

NS, no sample.

involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to one of our laboratories for analysis. Due to the different sensitivity of procedures used by the three laboratories, the minimum detectable concentration varies. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for July-September 1971. The average tritium concentration was 0.2 nCi/liter.

The radiation dose resulting from the observed tritium concentrations in the drinking water may be evaluated by using the relationship derived by Moghissi and Porter (3) from recommendations of the International Commission on Radiological Units and Measurements (4). Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.5 nCi/liter during the third quarter. This corresponds to a dose of 0.3 mrem/a, or less than 0.2 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 3.9 nCi/liter for the third quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.6 mrem/a, or 0.4 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

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Table 2. Tritium concentration in surface water, July–September 1971

Location		Water source	Facility	Collection date (1971)	Concentration (nCi/liter ±2σ)
Ala:	Decatur	Tennessee River	Browns Ferry	7/3	0.6 ±0.2
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	7/19	[a]0
Calif:	Eureka	Humboldt Bay	Humboldt Bay	7/26	0
	San Onofre	Pacific Ocean	San Onofre	7/8	0
Colo:	Greely	South Platte River	Fort St. Vrain	7/11	1.1 ± .4
Conn:	East Haddam	Connecticut River	Connecticut Yankee and Vermont Yankee	7/22	.8 ± .4
	Waterford	Long Island Sound	Millstone	7/22	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	9/22	[a]0
	Homestead	Biscayne Bay	Turkey Point	9/22	[a]0
Idaho:	Buhl	Snake River	National Reactor Testing Station	7/9	0
Ill:	Moline	Mississippi River	Quad-Cities	7/22	0
	Morris	Illinois River	Dresden and Argonne	7/26	.5 ± .4
La:	New Orleans	Mississippi River	(Several)	7/12	.5 ± .2
Md:	Conowingo	Susquehanna River	Peach Bottom and Three-Mile-Island	7/14	.5 ± .4
	Lusby	Chesapeake Bay	Calvert Cliffs	7/20	0
Mass:	Rowe	Deerfield River	Yankee	7/15	3.8 ± .4
Mich:	Charlevoix	Lake Michigan	Big Rock Point	8/14	0
	Monroe	Lake Erie	Enrico Fermi	8/16	.6 ± .4
	South Haven	Lake Michigan	Palisades	8/9	0
Minn:	Monticello	Mississippi River	Monticello	7/6	.6 ± .4
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	7/1	.9 ± .4
Nev:	Boulder City	Colorado River	Background	7/6	1.3 ± .4
N.J:	Bayside	Delaware River	Salem	7/7	0
N.Y:	Ossining	Hudson River	Indian Point	8/2	.7 ± .4
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	7/12	0
	Poughkeepsie	Hudson River	Background	7/21	0
N.C:	Charlotte	Catawba River	Wm. B. McGuire	9/16	.5 ± .2
Oreg:	Westport	Columbia River	Rainier and Hanford	8/24	.6 ± .4
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	7/10	3.9 ± .2
	Hartsville	Lake Robinson	H. B. Robinson	9/18	.6 ± .2
Tenn:	Kingston	Clinch River	Oak Ridge	7/27	1.9 ± .2
Tex:	El Paso	Rio Grande River	Los Alamos	7/6	.6 ± .4
Vt:	Vernon	Connecticut River	Vermont Yankee	7/12	0
Va:	Newport News	James River	Surry	7/10	.3 ± .2
Wash:	Northport	Columbia River	Background	7/16	.7 ± .4
	Pasco	Columbia River	Hanford	7/2	.8 ± .4
W. Va:	Wheeling	Ohio River	Shippingport	7/13	0
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	7/19	0
	Victory	Mississippi River	LaCrosse and Prairie Island	7/15	.6 ± .4
Average[b]					0.6

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For al other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

Table 3. Tritium concentration in precipitation from RAN stations, July–September 1971

Location		Tritium concentration[a] (nCi/liter ±2 σ)		
		July	August	September
Ala:	Montgomery	0.4 ±0.2	0.8 ±0.2	0
Alaska:	Anchorage	.6 ± .2	NS	0
Colo:	Denver	1.2 ± .2	.7 ± .2	0.7 ±0.2
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	NS	0
N.C:	Gastonia	.3 ± .2	0	NS
Tex:	Austin	NS	NS	NS
Wash:	Seattle	.7 ± .2	.3 ± .2	0

[a] The minimum detection limit for these samples was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero.

NS, no sample.

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1970	May 1971
January-March 1971	July 1971
April-June 1971	November 1971

REFERENCES

(*1*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11:638–639 (November 1970).

(*2*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July-December 1969. Radiol Health Data Rep 11:354–355 (July 1970).

(*3*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL UNITS AND MEASUREMENTS. Recommendations of the International Commission of Radiological Units and Measurements, National Bureau of Standards Handbook 85 (1964).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the California State Department of Public Health, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports:*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican Air Monitoring Program	August-December 1970 and January 1971	October 1971
Plutonium in Airborne Particulates	April-June 1971	March 1972
Surface Air Sampling Program 80th Meridian Network, *HASL*	January-December 1969	February 1972

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1. Radiation Alert Network December 1971

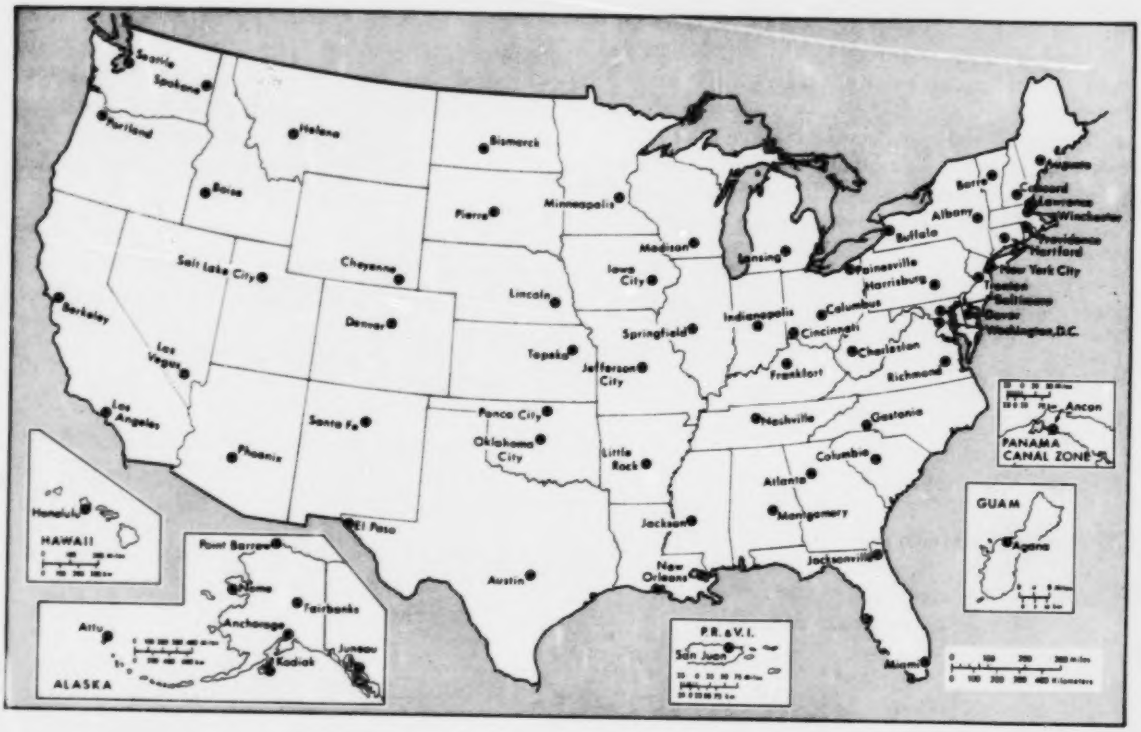
Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, North Carolina 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during December 1971.

All field estimates reported were within normal limits for the reporting station.


Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
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Lawrence
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Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
Kodiak
ALASKA
P.R. & V.I.
San Juan
PANAMA CANAL ZONE
Ancon
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, December 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	2	0	1	5	56	5	56	18
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	30	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	14	10	3	5	0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	12	1	0	0	8	104	8	104	0
	Los Angeles	23	3	0	1	0				
C.Z:	Ancon	17	0	0	0	0				
Colo:	Denver	22	5	1	2	1	1	(b)		
Conn:	Hartford	18	0	0	0	5	39	5	39	0
Del:	Dover	20	1	0	0	0				
D.C:	Washington	14	1	0	0	0				
Fla:	Jacksonville	19	1	0	0	4	92	2	31	0
	Miami	17	0	0	0	3	60	2	60	0
Ga:	Atlanta	22	2	0	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	21	1	0	0	7	52	(b)		
Idaho:	Boise	21	1	0	0	8	38	8	38	0
Ill:	Springfield	11	2	0	1	0				
Ind:	Indianapolis	20	1	0	0	0				
Iowa:	Iowa City	20	1	0	1	3	78	3	78	0
Kans:	Topeka	20	2	0	1	6	57	6	57	7
Ky:	Frankfort	0				0				
La:	New Orleans	19	0	0	0	7	144	(b)		
Maine:	Augusta	19	0	0	0	6	35	6	35	0
Md:	Baltimore	20	1	0	0	2	12	2	12	0
Mass:	Lawrence	20	0	0	0	5	48	5	48	0
	Winchester	19	1	0	0	7	36	7	36	0
Mich:	Lansing	19	1	0	0	0				
Minn:	Minneapolis	20	1	0	0	4	10	4	10	2
Miss:	Jackson	16	1	0	0	7	207	7	207	0
Mo:	Jefferson City	21	2	0	1	8	110	8	110	0
Mont:	Helena	20	2	0	1	1	13	1	13	0
Nebr:	Lincoln	19	8	1	2	1	1	1	1	0
Nev:	Las Vegas	16	5	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	21	1	0	0	6	28	6	28	1
N. Mex:	Santa Fe	16	1	0	0	0				
N.Y:	Albany	23	1	0	0	0				
	Buffalo	19	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	5	1	2	0		(b)		
N. Dak	Bismarck	22	2	0	1	4	11	4	11	1
Ohio:	Cincinnati	0				0				
	Columbus	3	1	0	0	0				
	Painesville	21	1	0	0	7	50	7	50	11
Okla:	Oklahoma City	0				0				
	Ponca City	21	2	0	1	7	75	7	75	0
Oreg:	Portland	21	1	0	0	15	225	15	225	10
Pa:	Harrisburg	15	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	22	1	0	0	0				
S.C:	Columbia	13	2	0	1	3	68	3	68	0
S. Dak:	Pierre	21	4	0	1	0				
Tenn:	Nashville	18	1	0	0	11	120	11	120	2
Tex:	Austin	14	4	0	1	6	87	(b)		
	El Paso	5	2	1	1	0				
Utah:	Salt Lake City	28	1	0	0	10	20	10	20	0
Vt:	Barre	18	1	0	0	8	41	8	41	3
Va:	Richmond	22	1	0	0	1	2	1	2	1
Wash:	Seattle	9	0	0	0	9	116	(b)		
	Spokane	21	1	0	0	0				
W. Va:	Charleston	20	[illegible]	0	1	6	32	6	32	6
Wisc:	Madison	23	[illegible]	0	0	7	96	7	96	6
Wyo:	Cheyenne	23	5	0	2	0				
Network summary		1,048	10	0	1	193	75	6	59	2

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] December 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for December 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, December 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	23	0.2	0.0	0.1	NS	NS
Coral Harbour	23	.1	.0	.1	6	0.3
Edmonton	23	.2	.0	.1	8	.4
Ft. Churchill	24	.1	.0	.1	28	.3
Fredericton	21	.1	.0	.1	19	1.2
Goose Bay	24	.1	.0	.1	8	.4
Halifax	24	.2	.0	.1	14	1.7
Inuvik	24	.1	.0	.1	31	.4
Montreal	24	.1	.0	.0	20	1.7
Moosonee	24	.1	.0	.1	4	.2
Ottawa	24	.1	.0	.1	21	1.8
Quebec	24	.1	.0	.1	7	.8
Regina	23	.2	.1	.1	40	.6
Resolute	24	.1	.1	.1	36	.1
St. John's, Nfld	24	.2	.0	.0	17	.9
Saskatoon	24	.1	.1	.1	11	.4
Sault Ste. Marie	NS				16	1.5
Thunder Bay	24	.4	.0	.1	17	.7
Toronto	24	.4	.0	.1	14	1.3
Vancouver	24	.3	.0	.0	12	2.4
Whitehorse	24	.1	.0	.1	18	.6
Windsor	24	.2	.0	.0	18	2.0
Winnipeg	24	.2	.0	.1	43	.3
Yellowknife	24	.2	.1	.1	11	.1
Network summary	545	0.4	0.0	0.1	17	0.8

NS, no sample.

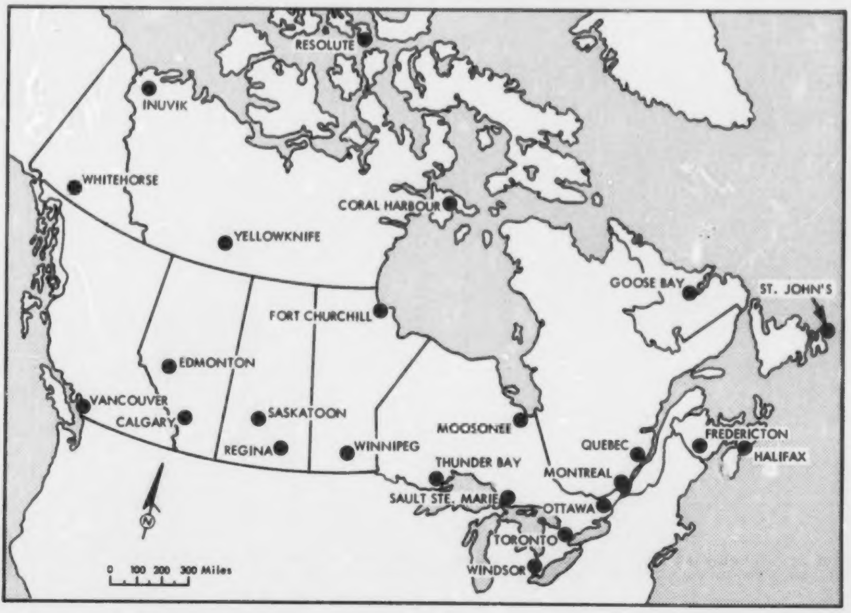
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program
December 1971

Pan American Health Organization and Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The December 1971 air monitoring results from the participating countries are given in table 3.

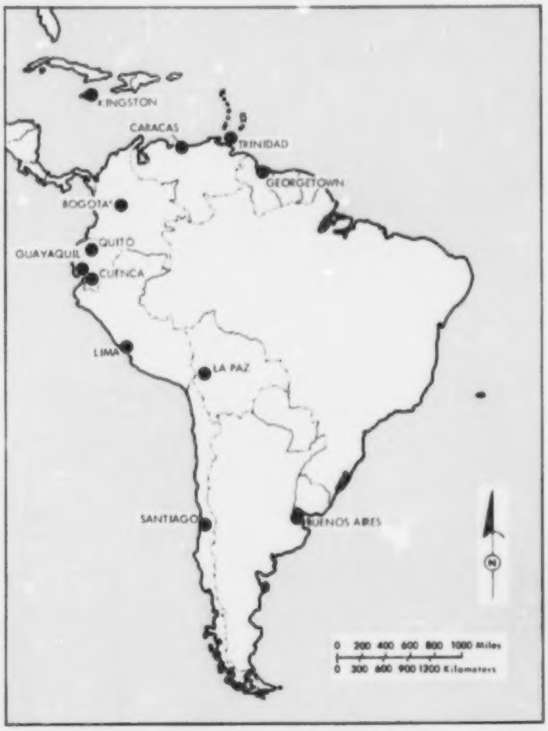

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, December 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	10	0.11	0.02	0.06
Chile:	Santiago	30	.38	.03	.20
Colombia:	Bogota	20	.06	.00	.02
Ecuador:	Cuenca	6	.03	.01	.02
	Guayaquil	9	.29	.11	.19
	Quito	7	.03	.01	.02
Guyana:	Georgetown	10	.03	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	10	.05	.01	.02
West Indies:	Trinidad	5	.02	.01	.02
Pan American summary		107	0.38	0.00	0.09

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program
December 1971

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size,

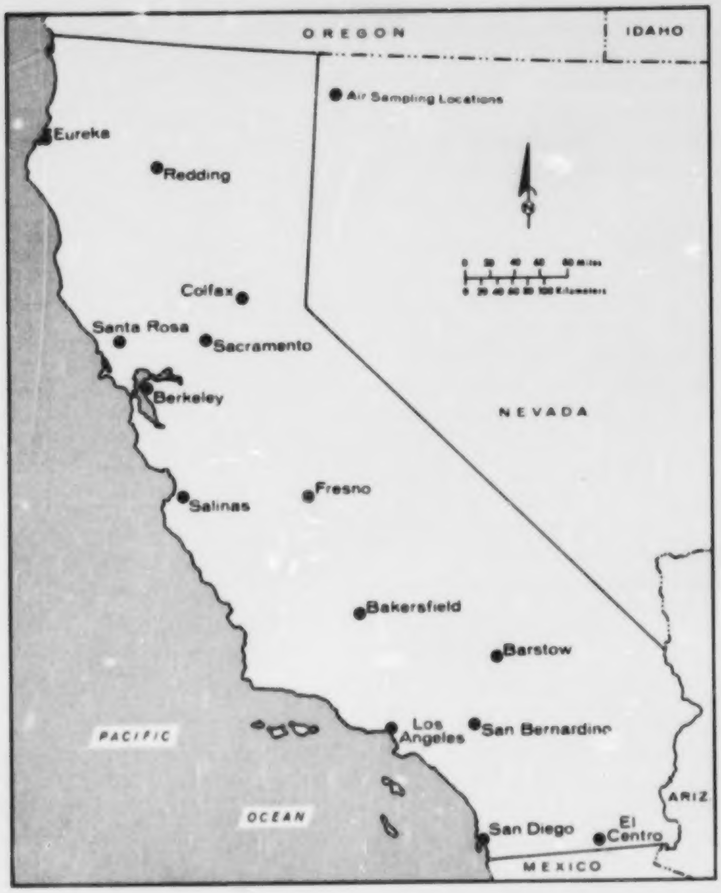
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Fresno
Salinas
Bakersfield
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
San Diego
El Centro
ARIZ
MEXICO
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers

Figure 4. California Air Sampling Program stations

using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma-scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for the month of December 1971.

Table 4. Gross beta radioactivity in California air December 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	31	0.87	0.00	0.23
Barstow	31	.77	.06	.25
Berkeley	30	.68	.00	.18
Colfax	31	.44	.00	.12
El Centro	31	.87	.07	.33
Eureka	29	.33	.03	.10
Fresno	31	1.16	.03	.21
Los Angeles	31	.43	.06	.18
Redding	30	.47	.03	.12
Sacramento	26	.79	.00	.21
Salinas	31	1.44	.02	.30
San Bernardino	10	.30	.09	.21
San Diego	31	.35	.02	.15
Santa Rosa	25	.71	.02	.16
Summary	398	1.44	0.00	0.20

5. Plutonium in Airborne Particulates July–September 1971

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Office of Air Programs, Environmental Protection Agency, routinely collects airborne particulate samples from eleven selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for July-September 1971 are presented in table 5. The minimum detectable activities are 0.020 pCi and 0.015 pCi per samples for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Other coverage in *Radiation Data and Reports:*

Period	Issue
January-June 1970	March 1971
July-December 1970	June 1971
January-March 1971	November 1971
April-June 1971	March 1972

Table 5. Plutonium in airborne particulates July–September 1971

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	^{239}Pu/^{238}Pu
Alaska:	Anchorage	ND	11 ±2	
Ariz:	Phoenix	7 ±3	58 ±11	8 ±4
Colo:	Denver	2 ±1	66 ±5	33 ±17
Hawaii:	Honolulu	ND	40 ±4	
La:	New Orleans	ND	28 ±3	
Md:	Baltimore	2 ±1	62 ±5	31 ±16
N.Y:	Buffalo	5 ±2	84 ±9	17 ±7
N.C:	Gastonia	ND	53 ±3	
S. Dak:	Pierre	4 ±1	79 ±6	20 ±5
Tex:	Austin	NS		
Wash:	Seattle	3 ±1	42 ±5	14 ±5

ND, nondetectable.
NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Deportment of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-December 1969. Radiol Health Data Rep 11:552-553 (October 1970).

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Air Surveillance Network, October-November 1971

Western Environmental Research Laboratory
Environmental Protection Agency
Las Vegas, Nev.

The Air Surveillance Network (ASN), operated by the Western Environmental Research Laboratory (WERL), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

The stations are operated by State health department personnel and by private individ-

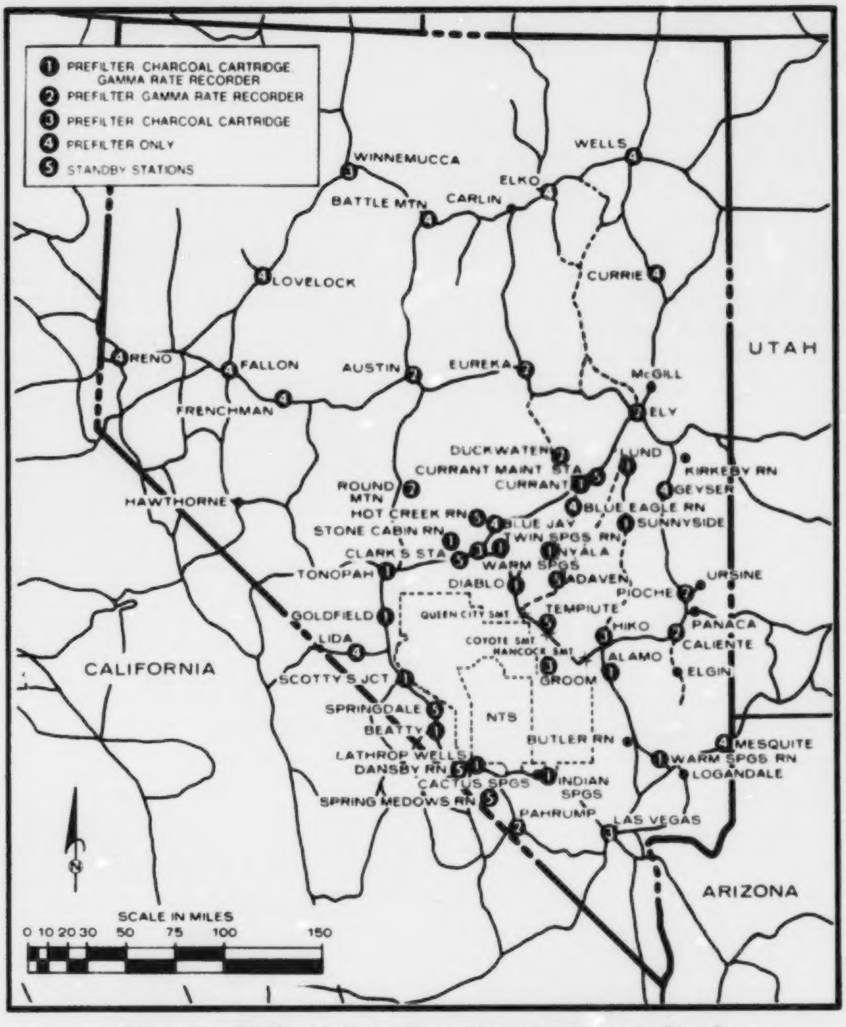
❶ PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
❷ PREFILTER GAMMA RATE RECORDER
❸ PREFILTER CHARCOAL CARTRIDGE
❹ PREFILTER ONLY
❺ STANDBY STATIONS
WINNEMUCCA
WELLS
ELKO
BATTLE MTN
CARLIN
LOVELOCK
CURRIE
UTAH
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT STA
KIRKEBY RN
ROUND MTN
CURRANT
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE JAY
BLUE EAGLE RN
SUNNYSIDE
STONE CABIN RN
TWIN SPGS RN
CLARK'S STA
NYALA
WARM SPGS
URSINE
TONOPAH
DIABLO
ADAVEN
PIOCHE
TEMPIUTE
GOLDFIELD
QUEEN CITY SMT
HIKO
PANACA
LIDA
COYOTE SMT
HANCOCK SMT
CALIENTE
ALAMO
CALIFORNIA
SCOTTY'S JCT
GROOM
ELGIN
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEDOWS RN
PAHRUMP
LAS VEGAS
N
ARIZONA
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. WERL Air Surveillance Network stations in Nevada

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[1] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

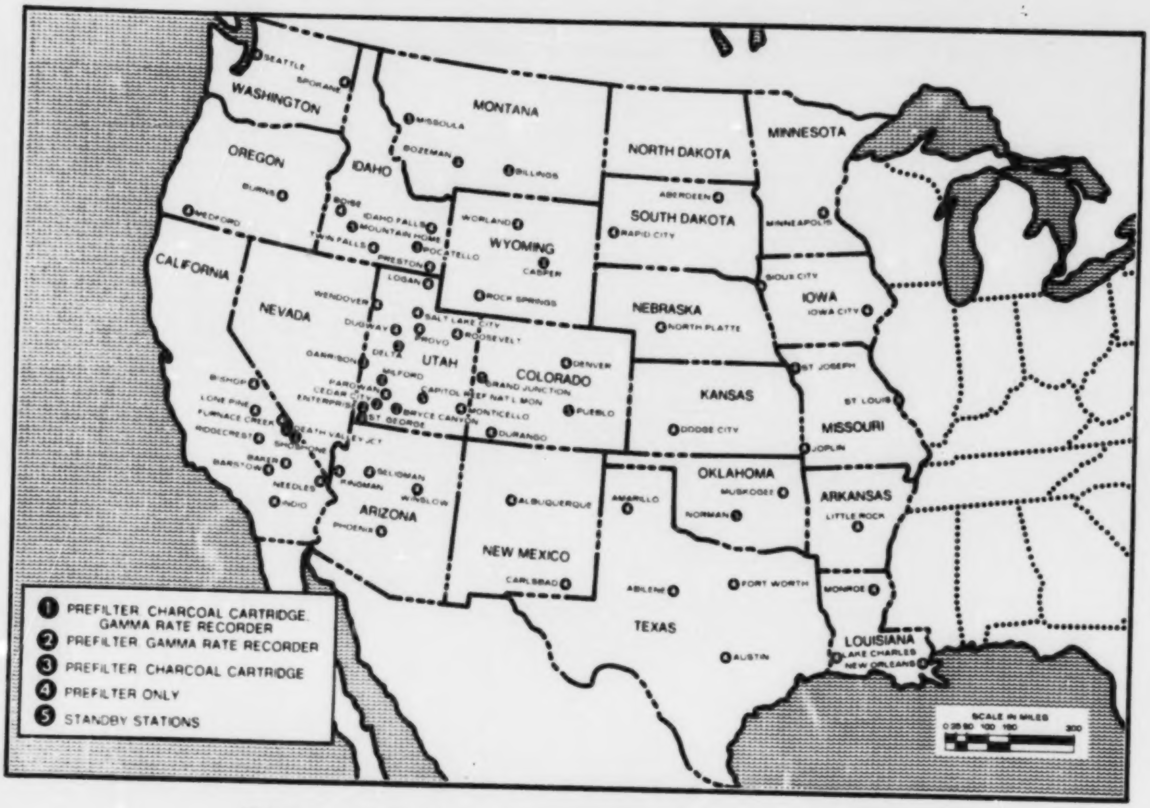
WASHINGTON
SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
CALIFORNIA
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
NEVADA
DEATH VALLEY JCT
UTAH
LOGAN
WENDOVER
DUGWAY
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
GARRISON
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST GEORGE
BRYCE CANYON
CAPITOL REEF NAT L MON
MONTICELLO
COLORADO
GRAND JUNCTION
DENVER
PUEBLO
DURANGO
ARIZONA
SELIGMAN
KINGMAN
WINSLOW
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
NEBRASKA
NORTH PLATTE
KANSAS
DODGE CITY
OKLAHOMA
MUSKOGEE
NORMAN
TEXAS
AMARILLO
ABILENE
FORT WORTH
AUSTIN
MINNESOTA
MINNEAPOLIS
IOWA
SIOUX CITY
IOWA CITY
MISSOURI
ST JOSEPH
ST LOUIS
JOPLIN
ARKANSAS
LITTLE ROCK
LOUISIANA
MONROE
LAKE CHARLES
NEW ORLEANS
❶ PREFILTER CHARCOAL CARTRIDGE. GAMMA RATE RECORDER
❷ PREFILTER GAMMA RATE RECORDER
❸ PREFILTER CHARCOAL CARTRIDGE
❹ PREFILTER ONLY
❺ STANDBY STATIONS
SCALE IN MILES
0 25 50 100 150 200

Figure 2. WERL Air Surveillance Network stations outside Nevada

uals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta radiation in air particulates during October 1971; table 2 presents the data for November 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m^3. For averaging purposes individual concentrations which are below the minimum detectable concentration (0.06-0.07 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3.

No radionuclides were identified by gamma spectrometry on any filters collected during October. No radioactivity was identified on any of the charcoal cartridges.

From gamma spectrometry results, fresh fission products in varying combinations of cerium-141, tellurium-132, iodine-131, and barium-140 were identified on filters collected in Arizona, California, Colorado, Idaho, Louisiana, Missouri, Nebraska, Nevada, New Mexico, Texas, Utah, and Wyoming during November. The highest concentrations of these radionuclides respectively, were 1.4 pCi/m^3 (Reno), 2.0 pCi/m^3 (Winnemucca), 2.4 pCi/m^3 (Reno), and 3.3 pCi/m^3 (Reno). These radionuclides and higher than normal gross beta concentrations may have resulted from a non-U.S. nuclear test conducted on November 18, 1971.

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Table 1. Summary of gross beta radioactivity concentrations in air, October 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	30	0.4	0.1	0.2
	Phoenix	31	.4	<.1	.2
	Seligman	31	.5	<.1	.2
	Winslow	31	.6	<.1	.2
Ark:	Little Rock	11	.7	<.1	.2
Calif:	Baker	27	.3	<.1	.2
	Barstow	31	.3	<.1	.2
	Bishop	31	.4	<.1	.2
	Death Valley Junction	30	.3	<.1	.2
	Furnace Creek	30	.3	<.1	.2
	Indio	31	.5	<.1	.2
	Lone Pine	23	.4	.1	.2
	Needles	27	.3	<.1	.2
	Ridgecrest	31	.2	<.1	.2
	Shoshone	31	.4	<.1	.2
Colo:	Denver	19	.2	<.1	.1
	Durango	31	.3	<.1	.2
Idaho:	Boise	31	.3	<.1	.1
	Idaho Falls	20	.2	<.1	.1
	Preston	31	.3	<.1	.1
	Twin Falls	31	.3	<.1	.1
Iowa:	Iowa City	20	<.5	<.1	.1
	Sioux City	27	.3	.1	.1
Kans:	Dodge City	31	.2	<.1	.1
La:	Lake Charles	16	.3	.1	.1
	Monroe	19	.3	<.1	.1
	New Orleans	21	.3	.1	.1
Minn:	Minneapolis	18	.2	.1	.1
Mo:	Joplin	30	.2	<.1	.1
	St. Joseph	31	.3	<.1	.1
	St. Louis	30	.5	<.1	.2
Nebr:	North Platte	25	.3	.1	.2
Nev:	Alamo	31	.5	<.1	.2
	Austin	24	.3	.1	.1
	Battle Mountain	29	.2	<.1	.1
	Beatty	31	.3	.1	.2
	Blue Eagle Ranch (Currant)	30	.5	<.1	.2
	Blue Jay	31	.5	<.1	.2
	Caliente	31	.3	<.1	.2
	Currant Ranch	28	.2	<.1	.1
	Currie	31	.4	<.1	.2
	Diablo	31	.3	<.1	.2
	Duckwater	26	.3	<.1	.1
	Elko	31	.2	<.1	.1
	Ely	28	.3	<.1	.2
	Eureka	30	.4	<.1	.2
	Fallini's Twin Springs Ranch	31	.4	.1	.2
	Fallon	31	.3	<.1	.2
	Frenchman Station	31	.3	<.1	.2
	Geyser Maintenance Station	27	.3	<.1	.1
	Goldfield	30	.3	<.1	.2
	Groom Lake	30	.5	<.1	.2
	Hiko	31	.4	<.1	.2
	Indian Springs	31	.3	<.1	.2
	Las Vegas	17	.3	.1	.2
	Lathrop Wells	30	.3	<.1	.2
	Lida	30	.3	.1	.2
	Lovelock	31	.3	<.1	.1
	Lund	26	.4	<.1	.2
	Mesquite	31	.4	.1	.2
	Nyala	31	.4	.1	.2
	Pahrump	18	.3	.1	.1
	Pioche	31	.3	<.1	.1
	Reno	30	.2	<.1	.1
	Round Mountain	28	.3	.1	.2
	Scotty's Junction	31	.3	.1	.2
	Stone Cabin Ranch	31	.3	<.1	.2
	Sunnyside	13	.3	<.1	.1
	Tonopah	30	.3	<.1	.2
	Tonopah Test Range	28	.4	<.1	.2
	Warm Springs Ranch	31	.3	<.1	.1
	Wells	31	.3	<.1	.1
	Winnemucca	31	.3	<.1	.1
N. Mex:	Albuquerque	21	.4	<.1	.2
	Carlsbad	31	.6	<.1	.2
Okla:	Muskogee	28	.3	.1	.1
Oreg:	Burns	31	.2	<.1	.1
	Medford	18	.2	.1	.1
S. Dak:	Aberdeen	31	.4	<.1	.1
	Rapid City	29	.2	<.1	.1
Tex:	Abilene	28	.4	<.1	.2
	Amarillo	31	.5	<.1	.2
	Austin	7	.2	.1	.1
	Fort Worth	29	.4	<.1	.2
Utah:	Bryce Canyon	22	.2	<.1	.1
	Cedar City	30	.3	<.1	.1
	Delta	31	.3	<.1	.2
	Dugway	31	.3	<.1	.2

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Table 1. Summary of gross beta radioactivity concentrations in air, October 1971—continued

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Enterprise	31	.4	<.1	.1
	Garrison	31	.4	<.1	.2
	Logan	30	.3	.1	.2
	Milford	31	.5	<.1	.2
	Monticello	22	.2	<.1	.1
	Parowan	31	.3	<.1	.1
	Provo	29	.3	<.1	.1
	Roosevelt	31	.3	<.1	.1
	Salt Lake City	31	.3	.1	.1
	St. George	32	.3	<.1	.2
	Wendover	31	.3	<.1	.2
Wash:	Seattle	19	.1	<.1	.1
	Spokane	17	.1	<.1	.1
Wyo:	Rock Springs	31	.3	<.1	.1
	Worland	31	.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1 pCi/m³.

Table 2. Summary of gross beta radioactivity concentrations in air, November 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	30	18.0	<0.1	1.5
	Phoenix	29	3.0	<.1	.5
	Seligman	30	14.0	.1	1.1
	Winslow	30	7.8	<.1	.6
Ark:	Little Rock	10	.7	<.1	.2
Calif:	Baker	24	15.0	<.1	1.1
	Barstow	30	32.0	<.1	1.5
	Bishop	29	31.0	<.1	2.4
	Death Valley Junction	28	6.4	<.1	.4
	Furnace Creek	28	.9	<.1	.2
	Indio	30	4.9	<.1	.5
	Lone Pine	26	16.0	.1	1.2
	Needles	24	11.0	<.1	.8
	Ridgecrest	30	7.1	<.1	.6
	Shoshone	31	8.1	<.1	.6
Colo:	Denver	22	1.1	.1	.3
	Durango	30	3.2	<.1	.3
Idaho:	Boise	29	3.3	<.1	.3
	Idaho Falls	21	2.9	.1	.3
	Preston	28	4.7	.1	.4
	Twin Falls	29	3.7	<.1	.3
Iowa:	Iowa City	18	.5	.1	.1
	Sioux City	26	.4	<.1	.1
Kans:	Dodge City	29	1.1	.1	.1
La:	Lake Charles	19	1.1	.1	.2
	Monroe	13	.3	.1	.1
	New Orleans	19	.7	.1	.2
Minn:	Minneapolis	20	.2	<.1	.1
Mo:	Joplin	30	.8	<.1	.2
	St. Joseph	30	1.4	<.1	.2
	St. Louis	30	.2	.1	.1
Nebr:	North Platte	25	1.5	<.1	.2
Nev:	Alamo	30	3.1	.1	.3
	Austin	28	30.0	<.1	1.8
	Battle Mountain	29	31.0	<.1	1.4
	Beatty	31	23.0	<.1	1.3
	Blue Eagle Ranch (Currant)	24	11.0	.1	.5
	Blue Jay	30	13.0	<.1	1.0
	Caliente	30	6.9	<.1	.5
	Currant Ranch	30	6.7	<.1	.5
	Currie	28	14.0	<.1	1.1
	Diablo	30	14.0	<.1	1.0
	Duckwater	23	15.0	<.1	.8
	Elko	30	20.0	<.1	1.1
	Ely	30	18.0	<.1	.9
	Eureka	29	22.0	<.1	1.6
	Fallini's Twin Springs Ranch	30	11.0	<.1	.8
	Fallon	30	51.0	<.1	2.7
	Frenchman Station	29	37.0	<.1	2.5
	Geyser Maintenance Station	30	14.0	.1	.8
	Goldfield	30	34.0	<.1	1.9
	Groom Lake	28	13.0	<.1	1.0
	Hiko	30	1.5	<.1	.2
	Indian Springs	31	4.5	<.1	.5

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Table 2. Summary of gross beta radioactivity concentrations in air, November 1971 —continued

Location		Number of samples	Concentration[a] (pCi/m^3)		
			Maximum	Minimum	Average
Nev:	Las Vegas	20	1.4	.1	.3
	Lathrop Wells	29	9.9	<.1	.6
	Lida	30	32.0	<.1	1.8
	Lovelock	30	14.0	<.1	1.1
	Lund	30	18.0	<.1	1.2
	Mesquite	30	2.7	<.1	.3
	Nyala	30	12.0	<.1	.7
	Pahrump	19	3.1	.1	.5
	Pioche	28	10.0	<.1	.7
	Reno	30	46.0	<.1	2.2
	Round Mountain	29	27.0	.1	1.6
	Scotty's Junction	29	18.0	<.1	1.5
	Stone Cabin Ranch	28	15.0	.1	1.2
	Sunnyside	13	15.0	<.1	2.4
	Tonopah	30	34.0	<.1	2.2
	Tonopah Test Range	24	15.0	<.1	1.7
	Warm Springs Ranch	30	1.6	<.1	.2
	Wells	30	21.0	<.1	.9
	Winnemucca	30	28.0	<.1	1.1
N. Mex:	Albuquerque	21	.2	<.1	.1
	Carlsbad	27	3.2	<.1	.4
Okla:	Muskogee	28	1.5	<.1	.2
Oreg:	Burns	30	2.1	<.1	.2
	Medford	24	2.3	<.1	.2
S. Dak:	Aberdeen	28	.7	<.1	.2
	Rapid City	30	.9	<.1	.1
Tex:	Abilene	28	9.2	.1	.6
	Amarillo	30	2.9	<.1	.3
	Austin	15	6.7	<.1	1.0
	Fort Worth	26	8.0	<.1	.6
Utah	Bryce Canyon	19	4.2	.1	.5
	Cedar City	26	8.0	<.1	.6
	Delta	29	8.7	<.1	.6
	Dugway	30	6.1	<.1	.5
	Enterprise	30	9.0	<.1	.6
	Garrison	30	8.8	<.1	.7
	Logan	30	2.2	<.1	.3
	Milford	30	8.9	<.1	.6
	Monticello	9	.5	.1	.1
	Parowan	26	.2	<.1	.1
	Provo	30	6.7	<.1	.5
	Roosevelt	30	7.6	<.1	.7
	Salt Lake City	30	5.3	<.1	.4
	St. George	30	3.2	<.1	.3
	Wendover	30	3.5	<.1	.3
Wash:	Seattle	22	.7	<.1	.1
	Spokane	17	.6	<.1	.1
Wyo:	Rock Springs	30	4.4	<.1	.3
	Worland	30	2.2	<.1	.2

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported as <0.1 pCi/m^3.

In support of the Cannikin Event, an underground nuclear detonation conducted November 6, 1971 on Amchitka Island, 15 additional air sampling stations were operated in Alaska during the latter part of October and the first half of November to supplement the regular network stations. Each air sampler used a glass-fiber filter and a charcoal cartridge. The analytical results for these stations will be published separately at a later date.[2]

Complete summaries of the daily station results are distributed to EPA regional offices and State health department offices. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

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[2] "Final Report, Off-Site Radiological Surveillance and Public Safety for the Cannikin Event, November 6, 1971." Western Environmental Research Laboratory, Environmental Protection Agency, Las Vegas, Nev. (To be published.)

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site July-December 1966 [1]

Western Environmental Research Laboratory, EPA and Nevada Operations Office, AEC

During July through December 1966, 10 announced underground nuclear tests were conducted by the U.S. Atomic Energy Commission (AEC) at their Nevada Test Site as a part of Operation Latchkey. In addition, Project Sterling was conducted underground in Mississippi as part of the Vela Uniform program. The Public Health Service (PHS) conducted a program of radiological environmental surveillance of the offsite area for the Safety Evaluation Division of the AEC's Nevada Operations Office under a Memorandum of Understanding between the PHS and AEC.

The Western Environmental Research Laboratory, EPA (WERL), formerly the Southwestern Radiological Health Laboratory, PHS, conducted this program of radiological monitoring and environmental sampling in the offsite areas surrounding the restricted area enclosed within the Nevada Test Site, Nuclear Rocket Development Station (NRDS), and the Nellis Air Force Range. The overall complex of the Nevada Test Site (NTS) and the Nellis Air Force Range includes the NRDS and the Tonopah Test Range (TTR) and for simplicity will be called the test range complex throughout this report. Although routine sampling and monitoring was done within a 300-mile radius around the test range complex, surveillance was extended as necessary to provide adequate coverage.

This report describes the methods and equipment used and summarizes the data collected during the 6-month period.

Operational procedures

Ground monitoring Prior to each event, mobile monitoring teams were deployed in the offsite area to locations most likely to be affected by a release of radioactive material. If a release did occur, the teams conducted a ground monitoring program directed from the AEC Control Point headquarters via two-way radio communications. Ground monitoring continued until activity levels essentially returned to background.

Each monitor was equipped with an Eberline E-500B, a Precision Model 111 Standard "Scintillator," and a Victoreen Radector Model No. AGB-50B-SR. The Eberline E-500B has a range of 0 to 200 mR/h beta-gamma detection in four scales with an external halogen-filled G-M tube and a 0 to 2,000 mR/h range gamma detection from an internal Anton 302 G-M tube. The Precision Model 111 Standard "Scintillator" was used primarily as an indicator of the presence of low levels of radioactivity since it provides a range of 0 to 5 mR/h in six scales. The Radector has a range of 0.05 to 50,000 mR/h over two logarithmic scales. This instrument has an inert gas ionization chamber as the detector. These instruments are accurate to ±20 percent as calibrated with cesium-137.

Exposure rate recorders To supplement the ground monitoring program, Eberline RM-11

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[1] This article is a summary of report number SWRHL-38r, "Off-site Surveillance Activities of the Southwestern Radiological Health Laboratory from June through December 1966."

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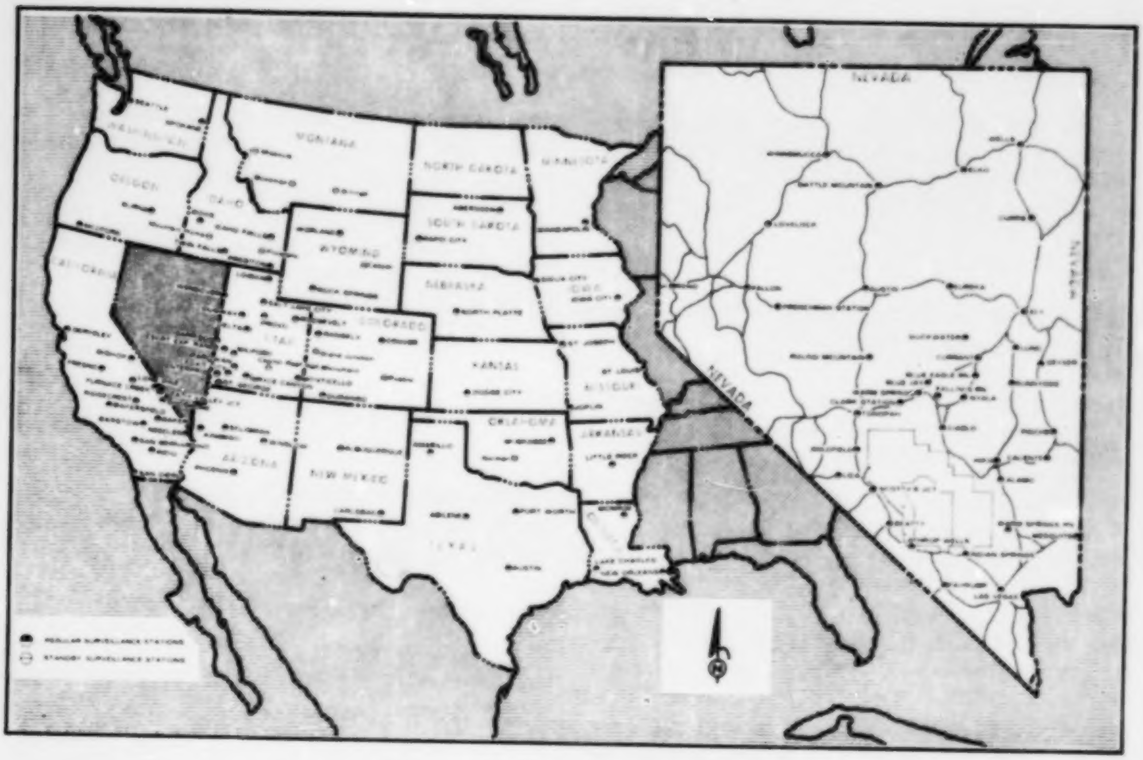
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OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
CALIFORNIA
UTAH
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
NEVADA
REGULAR SURVEILLANCE STATIONS
STANDBY SURVEILLANCE STATIONS

Figure 1. WERL Air Surveillance Network stations

exposure rate recorders were utilized to document cloud passage at fixed locations, thereby allowing mobile monitoring teams to continue following the release as it moved through the offsite area. These recorders have a Geiger tube detector and operate on 110 Vac. They have a 0.01 to 100 mR/h range and are calibrated to ±20 percent with a cesium-137 source. Gamma exposure rate is recorded on a 30-hour strip chart.

Aerial cloud tracking An Air Force U3-A aircraft with pilot and two monitors equipped with portable instruments identical to those of the ground monitors was used to track the effluent to assist in positioning ground monitors. Public Health Service cloud sampling aircraft were also used as aids in cloud tracking.

Air sampling During this 6-month period the WERL Air Surveillance Network consisted of 108 stations operating in every State west of the Mississippi except Montana and North Dakota (figure 1). The air sampler used in the Air Surveillance Network is a Gelman "Tempest." The "Tempest" Air Sampler consists of a Gast Model 1550 vacuum pump driven by a ½ horsepower electric motor. The pump runs at 1,440 rpm with an approximate flow rate of 10 cubic feet per minute. The sampler uses a 4-inch diameter Whatman 541 filter paper. An MSA charcoal cartridge can be added as necessary. The total volume of air sampled is calculated from an average vacuum reading and the total sampling time.

Milk and water sampling The previously established milk sampling program from both commercial dairies and private producers con-

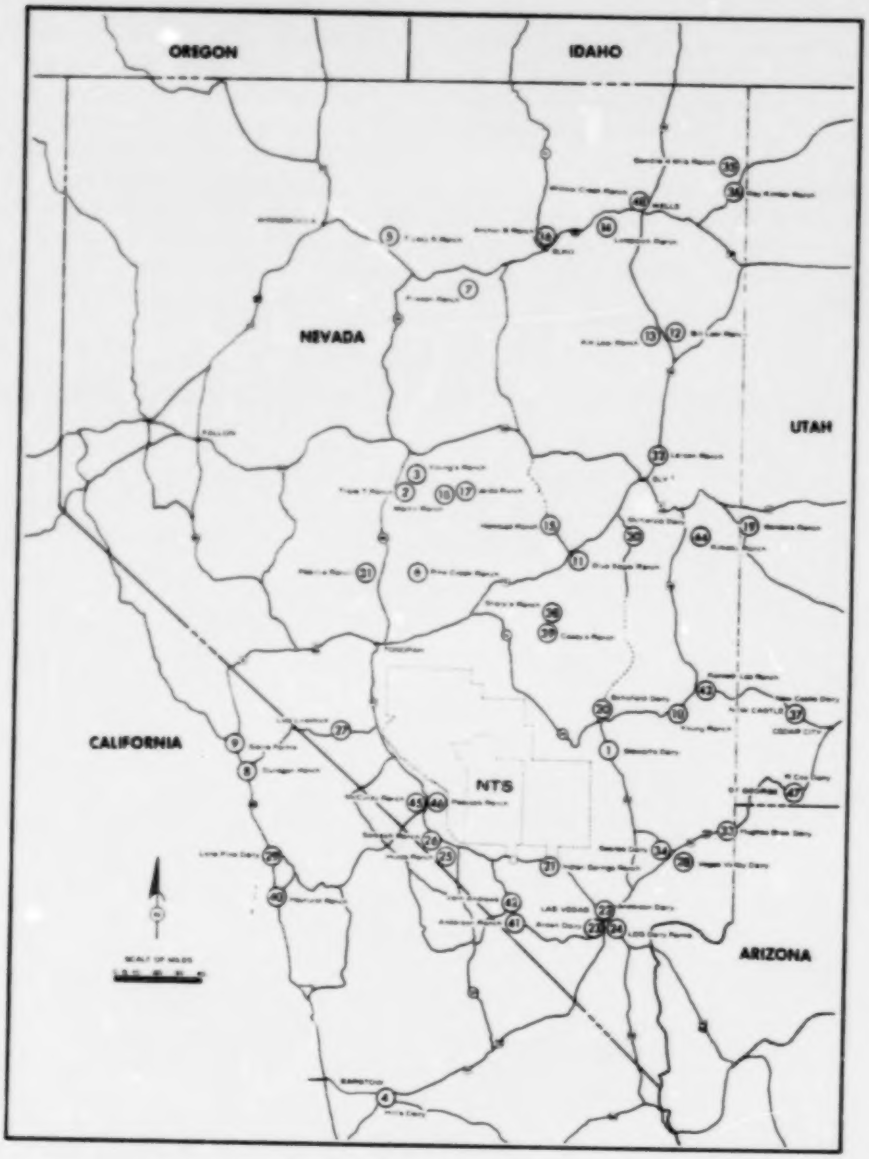
OREGON
IDAHO
NEVADA
UTAH
CALIFORNIA
NTS
ARIZONA
ELKO
WELLS
LAS VEGAS
CEDAR CITY
BARSTOW
SCALE OF MILES

Figure 2. Routine milk sampling stations around the Nevada Test Site

tinued throughout the 6-month period. About 30 sources were routinely sampled during this period (figure 2), many on a monthly basis. A total of 100 samples was collected from these locations. In the event of cloud passage over a specific area, intensified sampling within the area was conducted to document changes in activity.

Water samples were collected on a routine basis. Water sampling was increased when a release occurred; however, because there was only one slight release during this period, only one nonroutine sample was collected. Both potable and nonpotable water supplies were sampled routinely. During this period, 330 water samples were collected from about 70 sources (figure 3).

Vegetation sampling Normally, vegetation samples were collected only in the event of a release of radioactive material and analyzed for gross gamma radioactivity to delineate the fallout pattern.

Dosimetry Approximately 150 residents in the offsite area wore film badges throughout this period. These film badges were changed each month and were processed by the Radiological Sciences Department of Reynolds Electrical and Engineering Company, Inc. In addition, 65 film badge stations, each with five badges, were located around the test range complex to provide more complete coverage. These badges were also exchanged monthly.

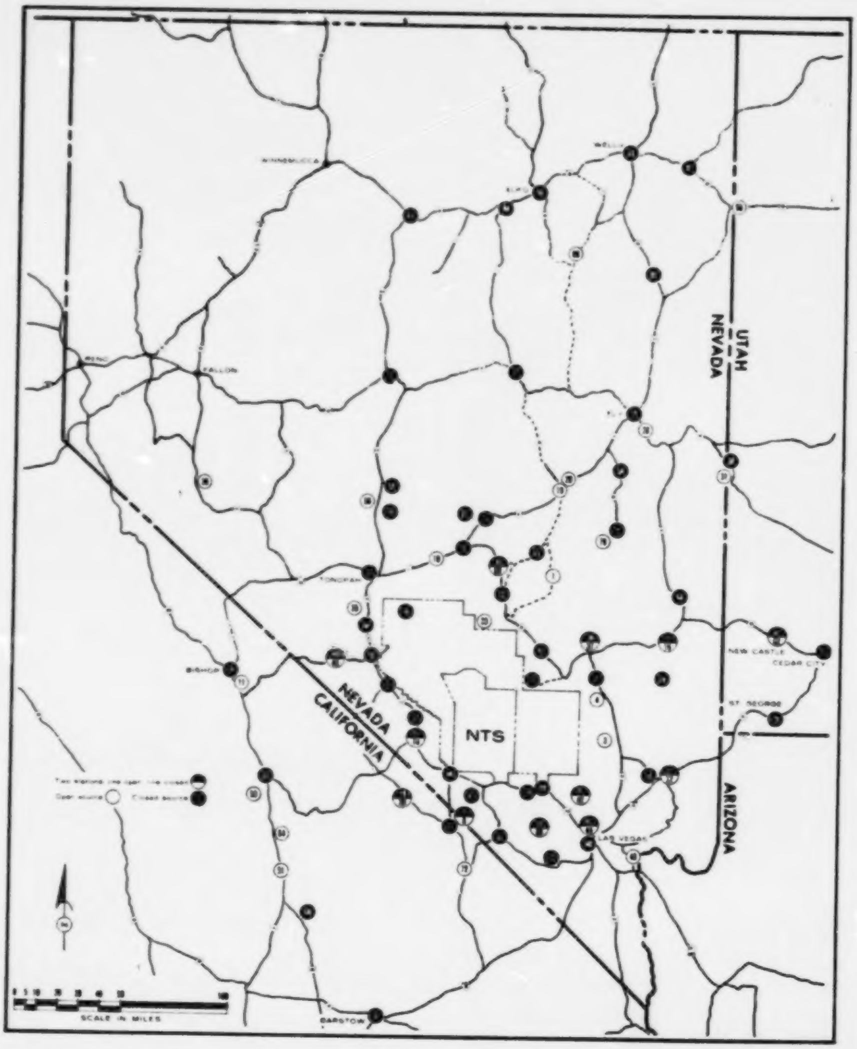
WINNEMUCCA
ELKO
WELLS
RENO
FALLON
ELY
UTAH
NEVADA
TONOPAH
BISHOP
NEVADA
CALIFORNIA
NTS
NEW CASTLE
CEDAR CITY
ST. GEORGE
ARIZONA
LAS VEGAS
BARSTOW
Two stations one open one closed
Open source
Closed source
SCALE IN MILES

Figure 3. Water sampling stations around the Nevada Test Site

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The badge used is made of DuPont type 555 film. The gamma exposure, as determined from this film, is accurate to ±50 percent in the 30 to 100 mR range and ±10 percent in the 100 to 2,000 mR range.

Approximately 20 of the 65 stations were each equipped with three CaF_2, thermoluminescent dosimeters (TLD) which were exchanged monthly with the film badges. The TLD's have a low energy photon response cutoff at 50 keV and are independent of energy in the range from 50 keV to several MeV. According to past TLD data, a reading at 10 mR above the previous month's background constitutes a detectable exposure.

Community relations Frequent contacts with the offsite population, schools and civic groups provided the opportunity to explain the role of the PHS in support of the programs of the AEC. As a result of favorable community relations, a number of offsite residents took part in the environmental sampling program; all routine air sampling stations except Las Vegas were operated by local citizens, and many people volunteered to wear film badge dosimeters.

Medical and veterinarian services A Public Health Service medical officer was available in the event any cases of a medical nature arose as a result of the test series. No such cases were brought to the attention of the PHS. Veterinarian services were provided by PHS veterinarians. Liaison was maintained with livestock producers in the area and the program of wildlife and cattle investigation was continued. Semiannual slaughter of cattle from the NTS herd and the Knoll Creek and Delmar Valley herds were accomplished in cooperation with the University of Nevada. Specimens from these animals were analyzed for radionuclide content.

Analytical procedures

All air sample prefilters and charcoal cartridges were returned to WERL in Las Vegas for radiological analyses. Prefilters were counted for gross beta activity in a Beckman "Wide Beta" low background (6 ± 1 cpm beta) proportional system which has an efficiency of approximately 45 percent for 0.54 MeV betas. After an initial count, if no significant activity was detected, the prefilters were counted at 5 and 12 days after collection. If significant fission product activity was indicated by the first count, prefilters were recounted a minimum of three times in the first 48 hours following collection. Results are then extrapolated to the end of the collection period by use of a decay constant empirically determined for each individual sample.

Selected prefilters and all charcoal cartridges were analyzed for gamma isotopes by placing them directly on a 4- by 4-inch NaI(Tl) crystal coupled to a TMC Model 404C gamma pulse height analyzer viewing energies from 0 to 2 MeV.

Detection capability of the system as shown in table 1 is an empirical estimate obtained from previous data collected under the following conditions:

1. count time in days after fissioning as indicated by footnotes,

Table 1. Threshhold detectability at time of count of several radionuclides in various samples (90 percent confidence level)

Sample number	Sample type	Iodine-131	Tellurium-iodine-132	Iodine-133	Iodine-135	Barium-lanthanum-140	Length of count
1[a]	Whatman No. 541 (pCi)	500	1,000	500	1,000	500	10 minutes
2[b]		200	-----	200	-----	200	10 minutes
3[a]	MSA charcoal (pCi)	200	400	200	400	200	10 minutes
4[b]		100	-----	100	-----	100	10 minutes
5[e]	3.5 liter water[d] (pCi/liter)	20	40–50	20–30	40–50	20	40 minutes
6[e]	3.5 liter milk[d] (pCi/liter)	20	-----	20–30	-----	20	40 minutes

[a] Counted at less than 3 days after formation.
[b] Counted at 3 days or more after formation.
[c] Assuming insignificant amounts of other nuclides, and all given isotopes at about detection limits to approximately 10 times the lower limit.
[d] Counted in 3.5 liter, inverted well (Marinelli), aluminum beakers.
[e] With cesium-137 ≤ 100 pCi/liter.

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2. prefilters collect unfractionated fission products resulting in a complex spectrum,
3. MSA charcoal predominately collects gaseous fission products (primarily iodines),
4. an eight isotope matrix is employed for computation and isotopes other than those examined are present in amounts which are small relative to those eight, and
5. natural activity on air samples is approximately five times system background.

Although the minimum detectable levels for water samples involve the limitations listed in 4 above, the situation is usually simplified by having no background other than that of the system. For a sample containing all of the isotopes of iodine, the error term on threshold values at the 95 percent confidence level is approximately equal to ±50 percent.

Biological discrimination limits the number of isotopes present in a milk sample. Under normal sampling procedures, this discrimination coupled with the short physical half-life will tend to eliminate iodine-132 and iodine-135 from the sample by the time it is counted. At the 95 percent confidence level reported values for milk are ±10 pCi/liter or 10 percent at the time of count, whichever is greater, for a 40-minute count.

After any release of activity from the NTS, milk samples are collected from dairies (processing plants), producing dairy farms, and farms producing milk for their own consumption. Each sample is counted for 40 minutes. No attempt is made to recount samples giving low positive values. The lower limit of detection for gamma emitters in milk samples is 20 pCi/liter at the time of count, and all results below that value are reported as <20 pCi/liter.

All liquid samples are counted in 3.5 liter, inverted-well, aluminum beakers which are placed on top of a 4- by 4-inch NaI(TI) crystal coupled to a 400-channel gamma pulse height analyzer. Overall detection efficiency for the 0.364 MeV photopeak of iodine-131 is 6.4 percent. A matrix technique is employed to compute the interference due to the presence of other isotopes. The input to this matrix is variable, allowing for the simultaneous determination of any eight nuclides for which detection efficiencies and interference factors have been obtained. Actual computation is performed by an IBM 1620 computer.

Water samples are analyzed for gross beta activity by slowly evaporating an aliquot to dryness in a 2-inch diameter stainless steel planchet and counting the beta activity in a low background counter.

Results

Only one of the 10 announced detonations at the Nevada Test Site resulted in a release of radioactive effluent which was detected offsite. This was the Derringer Event of September 12, 1966.

The only positive indication of Derringer effluent offsite was by ground monitoring. Two readings slightly above background were detected in unpopulated areas. Both radiation intensities were measured on a Model 111 "Scintillator" and were less than twice background. The readings were measured at 1115 Pdt at Hancock Summit on Highway 25 and at 1120 Pdt, 10 miles southeast of Coyote Summit on Highway 25. None of the Eberline RM-11 continuous exposure rate recorders located in areas off the Nevada Test Site showed a reading above background.

Thirty air samples were collected for this event. None of these samples showed an increase in gross beta radioactivity and no fresh fission products were detectable on the Whatman 541 filter or the MSA charcoal cartridge. Other samples collected included five milk samples, one water sample, and nine vegetation samples. Short-lived fresh fission products were not detectable in any of these samples.

All milk samples collected during this period are listed in tables 2 and 3. The Project Sterling underground test conducted in Mississippi on December 3, 1966, did not release radioactivity to the atmosphere.

One additional event of interest during this period was the Greeley Event, an underground nuclear detonation conducted at 0730 hours Pst on December 20, 1966, in the Pahute Mesa area of NTS. Although a release of radioactive effluent was not expected following this detonation, the PHS provided additional personnel

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Table 2. Potassium, strontium-90, and cesium-137 concentrations in milk, July–December 1966

Station	Date collected	Potassium (g/liter)	Concentration (pCi/liter)	
			Strontium-90	Cesium-137
California:				
Barstow, Hills Dairy	7/14	1.4	2	30
	8/23	1.2	4	<20
	9/15	1.2	2	<20
	10/20	1.4	.2	<20
	11/23	1.2	.9	<20
	12/14	1.0	<.1	35
Big Pine, Simmons Dairy	7/15	1.3	4	25
Bishop, Sierra Farms	7/15	1.3	6	<20
	8/25	1.2	5	20
	9/15	1.3	8	<20
	10/19	1.3	3.9	<20
	11/22	1.3	7.2	<20
	12/14	1.4	7.0	<20
Lone Pine, Lone Pine Dairy	7/14	1.2	3	45
	8/24	1.2	5	40
	9/15	1.2	3	<20
	10/20	1.2	1.4	<20
	11/22	1.4	4.0	<20
	12/14	1.3	2.8	<20
Olancha, Hayhurst Ranch	7/14	1.3	1	<20
	8/24	1.4	3	<20
	9/15	1.3	4	<20
	10/20	1.3	1.5	<20
	11/23	1.2	2.1	<20
	12/14	1.2	3.8	<20
Nevada:				
Alamo	7/14	1.2	1	25
Alamo, M. K. Stewart Dairy	7/15	1.3	2	20
	8/18	1.2	3	<20
	9/13	1.6	3	<20
	9/15	1.5	2	<20
	10/13	NA	4.1	<20
	11/16	1.2	4.3	<20
	12/22	1.5	2.6	<20
Alamo, L. L. Dairy	7/1	1.3	12	<20
	7/7	1.6	2	20
	7/14	1.2	1	25
	7/22	1.4	4	<20
	7/27	1.3	3	<20
	8/3	1.2	2	<20
Alamo, Wright Dairy	7/20	1.5	1	<20
Austin, Young Ranch	8/4	1.3	5	25
	8/31	1.6	7	<20
	9/28	1.6	7	<20
	11/3	1.5	7.6	<20
	12/1	1.4	12.2	20
Austin, Givens Ranch	7/21	1.7	9	25
	8/3	1.3	12	35
Baker, E. J. Cummings	7/5	1.5	3	<20
Baker, Baker Ranch	7/1	1.5	5	<20
Caliente, Young Ranch	7/19	1.4	2	<20
	8/18	1.3	1	<20
	9/14	NA	2	<20
	10/10	1.3	1.8	<20
	11/16	1.1	1.1	<20
	12/21	1.3	2.3	<20
Currant, Blue Eagle Ranch	8/24	1.6	4	35
	11/21	1.4	11.9	35
	12/19	1.5	10.6	55
Duckwater, Halstead Ranch	7/19	1.2	7	<20
	8/23	1.7	4	<20
	9/20	1.4	5	50
	10/18	1.3	1.8	<20
	11/18	1.1	4.8	<20
	12/19	1.4	5	<20
Duckwater, Blue Eagle Ranch	10/19	1.4	4.2	<20
Eureka, Willows Ranch	7/21	1.4	4	<20
	8/4	1.3	<.1	<20
	8/30	1.4	4	<20
	10/20	1.3	<.1	<20
Hiko, Davis Ranch	7/5	1.5	3	30
	7/12	1.3	3	30
	7/18	1.4	4	25
	7/26	1.4	4	25
	8/3	1.1	2	<20
Hiko, Schofield Dairy	7/14	1.4	2	<20
	8/18	1.3	2	<20
	9/13	1.4	3	<20
	9/15	1.6	3	<20
	10/13	NA	3.0	<20
	11/16	1.3	2.1	<20
	12/22	1.4	3.5	<20
Las Vegas, Anderson Dairy	7/6	NA	3	<20
	11/2	1.3	4.5	<20
Las Vegas, Arden Dairy	7/6	1.4	4	<20
	11/2	1.1	5	<20

See footnotes at end of table.

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Table 2. Potassium, strontium-90, and cesium-137 concentrations in milk, July–December 1966—continued

Station	Date collected	Potassium (g/liter)	Concentration (pCi/liter)	
			Strontium-90	Cesium-137
Nevada—continued				
Lathrop Wells, Damsby Ranch	8/30	1.3	1	<20
	12/27	1.1	.8	<20
Logandale, Vegas Valley Dairy or Farms	7/13	1.4	1	<20
	8/17	1.4	6	20
	9/9	1.4	4	<20
	10/25	1.3	4.6	<20
	11/28	1.2	2.6	<20
	12/29	1.3	1.7	<20
Lund	12/22	1.3	2.8	<20
Lund, McKenzie Dairy	7/8	1.5	3	25
	7/14	1.5	5	20
	7/22	1.4	3	<20
	7/29	NA	2	<20
	8/8	1.3	3	<20
	8/18	1.2	4	20
	8/30	1.4	4	<20
	9/5	1.4	3	25
	9/12	1.4	4	<20
	9/17	1.3	3	<20
	9/30	1.4	3	<20
	10/6	1.5	2	<20
	10/19	1.4	3.6	<20
	10/26	1.2	4.0	<20
	11/7	1.3	3.8	<20
	11/16	1.4	2.8	<20
	11/29	1.3	4.7	<20
	12/12	1.3	3.1	<20
	12/30	1.3	1.8	<20
Manhatten, Peavine Ranch	8/3	1.4	2	<20
	8/31	1.3	3	<20
	9/27	1.2	4	<20
	11/3	1.2	2.9	<20
Mesquite, Hughes Bros. Dairy	7/13	1.4	5	<20
	8/17	1.3	3	<20
	9/7	1.5	2	<20
	10/26	1.2	2.0	<20
	11/30	1.3	4.7	<20
	12/18	1.5	1.6	<20
Moapa, Searles Dairy	7/20	1.0	3	<20
	8/19	1.2	3	20
	10/28	1.2	3.1	20
Nyala, Sharp Ranch	7/14	1.2	11	65
	8/10	1.2	8	50
	9/15	1.5	8	<20
	10/5	1.6	11	50
	12/7	1.3	7.2	45
Pahrump, Ishmael Ranch	12/30	1.3	2.5	<20
Pioche, Horlacher Ranch	7/14	1.2	4	20
	8/17	1.4	5	30
	9/14	1.3	6	20
	10/12	1.0	4.4	<20
	11/16	1.1	8.3	<20
	12/23	1.4	4.8	25
Shoshone, Kirkeby Ranch	7/1	1.7	9	50
	7/23	1.6	10	25
	9/22	1.5	4	<20
	10/20	1.3	1.5	<20
	11/17	1.1	1.5	<20
Springdale, Peacock Ranch	11/16	1.3	1.5	<20
Tonopah, Sharps Ranch	9/8	1.5	15	<20
Winnemucca	11/8	1.2	4.7	<20
	11/10	1.1	2.9	<20
Winnemucca, P. Marcuerquiago	11/9	1.3	5.4	25
Winnemucca, 3V Dairy	11/10	1.2	3.6	<20
Utah:				
Garrison, Gonders Ranch	9/20	1.5	7	<20
	10/19	1.5	1.9	<20
	11/17	1.4	5.5	<20
Mt. Pleasant, Brooklawn Creamery	7/1	1.6	9	20
	7/2	1.4	12	<20
	7/3	1.4	9	<20
	7/4	1.3	10	<20
	7/5	1.3	11	20
New Castle, New Castle Dairy	7/14	1.4	4	<20
	8/17	1.2	5	<20
	9/8	1.4	3	<20
	10/26	1.3	4.6	<20
	12/1	1.2	4.1	<20
	12/17	1.2	2.3	<20
Ogden, Maple Leaf Dairy	7/1	1.1	10	20
	7/2	1.4	12	<20
	7/5	1.6	9	<20
	7/6	1.5	10	20

Table 2. Potassium, strontium-90 and cesium-137 concentrations in milk, July-December 1966 continued

Station	Date collected	Potassium (g/liter)	Concentration (pCi/liter)	
			Strontium-90	Cesium-137
St. George, Cox Dairy	7/15	1.4	4	<20
	7/29	1.4	5	<20
	8/6	1.4	3	<20
	8/12	1.3	5	<20
	8/19	1.3	[illegible]	<20
	8/26	1.3	3	<20
	9/2	1.3	3	<20
	9/12	1.2	8	<20
	9/16	1.3	6	25
	9/23	1.2	4	<20
	9/30	1.3	6	<20
	10/7	1.3	6	<20
	10/21	1.3	3.2	<20
	10/28	1.3	4.0	<20
	11/25	1.4	3.9	<20
	12/16	1.4	4.0	<20
	12/23	1.4	3.2	<20
St. George	7/1	1.3	3	<20
	7/22	1.1	5	<20
	10/14	1.4	3.5	<20
	11/3	1.3	3.9	<20
	11/11	1.4	5.4	<20
	11/18	1.3	3.7	<20
	12/2	1.3	2.5	<20
	12/9	1.4	3.5	<20
	12/30	1.4	4.3	<20
Smithfield	7/5	1.6	11	<20
	7/6	1.6	11	<20
	7/7	1.6	11	<20
Smithfield, Cache Valley Dairy	7/1	1.5	13	30
	7/2	1.4	10	25

NA, no analysis.

for ground motion studies because the Greeley device was of relatively large yield and ground motion was anticipated as far as 75 miles from ground zero.

Seventy-five personnel from WERL participated in the surveillance activities for this event. Community information centers were established in Tonopah, Goldfield, Beatty, and Alamo in order to inform the members of these communities of the exact time of the detonation and what degree of motion could be expected. PHS personnel were also available to answer questions in Ely, Caliente, Pioche, and Las Vegas.

All active mines in the vicinity of NTS were located and mining personnel were advised not to be underground at the time of the detonation.

No release of radioactive effluent occurred as a result of this detonation, either initially or in the followup operations. No damage to offsite structures from ground motion was reported to any of the community information centers.

Conclusions

Results obtained through environmental radiation surveillance during this period indicate that no individual in the offsite area received an exposure, resulting from Nevada Test Site operations, which exceeded the guides established by the AEC and/or recommended by the FRC and the NCRP.

Table 3. Strontium-89, iodine-131, ruthenium-103, and barium-140 in milk samples, July–December 1966

Station	Date collected	Concentration[a] (pCi/liter)			
		Strontium-89	Iodine-131	Ruthenium-103	Barium-140
California:					
Bishop, Sierra Farms	7/15	5			
Olancha, Hayhurst Ranch	7/14	5			
	11/23		50		
	12/14	5			
Nevada:					
Alamo	7/14	5			
Alamo, M. K. Stewart Dairy	7/15	5			
Alamo, L. Lee Dairy	7/1	5			
	7/14	5			
Austin, Givens Ranch	7/21	5	30		
Baker, E. J. Cummings	7/5	5			
Baker, Baker Ranch	7/1	5	20		
Caliente, Young Ranch	7/19		60		
Duckwater, Halstead Ranch	7/19	5			
	12/19			30	
Duckwater, Blue Eagle Ranch	10/19	5.5			
Hiko, Davis Ranch	7/5	5			
	7/12	5			30
	7/18	5	70		
Las Vegas, Arden Dairy	7/6	5			
Lathrop Wells, Dansby Ranch	8/30	5			
Logandale, Vegas Valley Dairy	7/13	5			
Lund, McKenzie Dairy	7/14	5			
	9/17	15			
Nyala, Sharp Ranch	12/7		10		
Pioche, Horlacher Ranch	7/14	10			
	12/23	6			
Shoshone, Kiekeby Ranch	7/23		60		
Springdale, Peacock Ranch	11/16	5			
Utah:					
Mt. Pleasant, Brooklawn Creamery	7/1	10			
	7/2	10			
	7/3	15			
	7/4	15			
	7/5	10			
New Castle, New Castle Dairy	7/14	5			
Ogden, Maple Leaf Dairy	7/1	5			
	7/5	5			
St. George, Cox Dairy	7/29	5			
St. George	7/1	5			
Smithfield	7/5	10			
	7/6	5			
	7/7	5			
Smithfield, Cache Valley Dairy	7/2	15			

[a] Only detectable concentrations of strontium-89, iodine-131, ruthenium-103, and barium-140 are listed. These radionuclides were nondetectable in all other samples.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of a nature that plant environmental surveys are required.

Releases of radioactivity materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for Neutron Devices Department and the Paducah Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Neutron Devices Department[2]
July–December 1970

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department (figure 1) is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Sewer effluent, surface water, milk and air within 6 miles of the plant are monitored for radioactivity. The radioactivity concentrations, weighted by atmospheric and stream dilution factors, are compared against the AEC standards for continuous nonoccupational exposure as presented in the AEC Manual, chapter 0524.

Sewer effluent monitoring

Waste water discharges from the plant were routinely sampled and analyzed for radioactive material at the site's boundary. A total of 214 samples was obtained and analyzed for tritium content. In those instances where detectable concentrations occurred, the radioactivity resulted from controlled releases. Radioactivity releases from the process waste system into the plant's water effluents resulted in an average tritium concentration for the period of less than 5 percent of the AEC standard for continuous nonoccupational exposure.

Surface water sampling

There were no indications of tritium in 127 routine surface water samples collected from areas surrounding the plant. These sample locations represent an area up to 6 miles in all directions from the plant site and are not related to the wastewater effluent from the plant.

Milk sampling results

Analyses of 12 raw milk samples, provided by the Pinellas County Health Department from the one local dairy farm, revealed no detectable concentrations (detectable level—90 nCi/liter) of tritium.

Air sampling results

A total of 12 air samples was obtained during times of radioactivity releases. Analyses of these samples revealed that the maximum concentration, occurring over a period of 30 minutes, represented only 3.6 percent of the AEC standard for tritium oxide in air for continuous nonoccupational exposure.

Summary

Offsite radioactivity concentrations encountered by the general population are substantially lower than the AEC standards for continuous nonoccupational exposure.

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[2] Summarized from "Environmental Monitoring, July 1 through December 1970," General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

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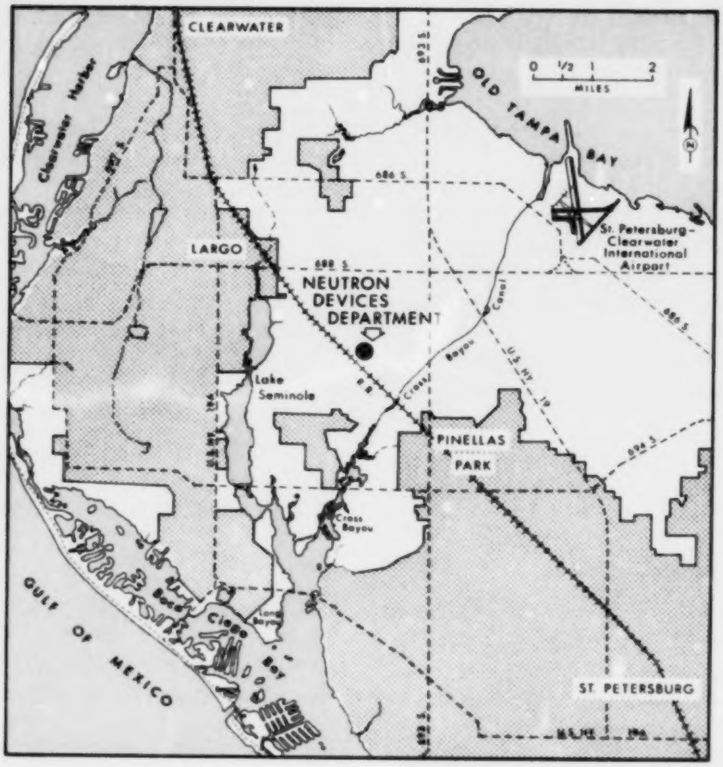
CLEARWATER
Clearwater Harbor
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LARGO
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NEUTRON DEVICES DEPARTMENT
Lake Seminole
R.R.
Cross Bayou Canal
U.S. HY 19
694 S
PINELLAS PARK
Cross Bayou
Long Bayou
Boca Ciega Bay
GULF OF MEXICO
ST. PETERSBURG

Figure 1. Location of the Neutron Devices Department

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1969	August 1970
January-June 1970	February 1971

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2. Paducah Plant[3]
July–December 1970

Union Carbide Corporation
Paducah, Ky.

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. Facilities on the site, in addition to the diffusion cascade, include a feed manufacturing plant, a metals plant, and a decontamination and uranium recovery unit.

The uranium enrichment areas (diffusion cascade) operate with a very low loss of material. Millions of pounds of uranium hexafluoride may be fed to, diffused in, and withdrawn from the cascade with the loss of only a few pounds per year. There is a slight loss of uranium to the atmosphere when diluent gasses are purged from equipment units or from the cascade. Some uranium on cascade equipment replaced for maintenance or modification is removed in the decontamination facility.

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[3] Summarized from "Environmental Concentrations of Radioactive Materials near the Paducah Plant—Report for the year 1970 and the second half of 1970."

The handling of powdered uranium salts in the feed manufacturing plant requires the extensive use of vacuum and local exhaust systems. Various filter units are used to remove uranium from exhaust air. The uranium hexafluoride product is separated from entrained solids, excess fluorine, and diluent gases by a series of cyclones, filters, cold condensers, and fluid bed absorbers. Unreacted uranium and beta active uranium decay products separated from the uranium hexafluoride in the fluorination system are stored for radioactive decay and processed through uranium recovery facilities.

The effluents to be considered in the handling of uranium solids and the use of vacuum and local exhaust systems in the metals plants are similar to those of the feed plant. In addition, the plant generates about 1,200 pounds of contaminated magnesium fluoride slag for every ton of uranium metal produced. This slag is collected and eventually buried onsite.

The environmental monitoring program provides for continuously sampling the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 2). Big Bayou and Little Bayou waters are sampled continuously, and grab samples are collected at five locations in the Ohio River and at the mouth of the combined Bayou Creeks. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed for the in-plant work environment of employees and for offsite exposure of the general population are those contained in Appendix 0524 of the AEC manual.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 5. The source of the radioactivity detected is considered to be uranium (alpha) and the radioactive daughters of uranium (beta). The average uranium concentration in air at the perimeter fence was 1 percent of the AEC standards for people residing in the vicinity of a controlled area. The average air concentration at the 1-mile stations was 0.5 percent of the AEC standard. The concentration of gross beta radioactivity was 0.04 percent and 0.02 percent of the AEC standard at the 1-mile stations, respectively. The average analysis of nine grab samples

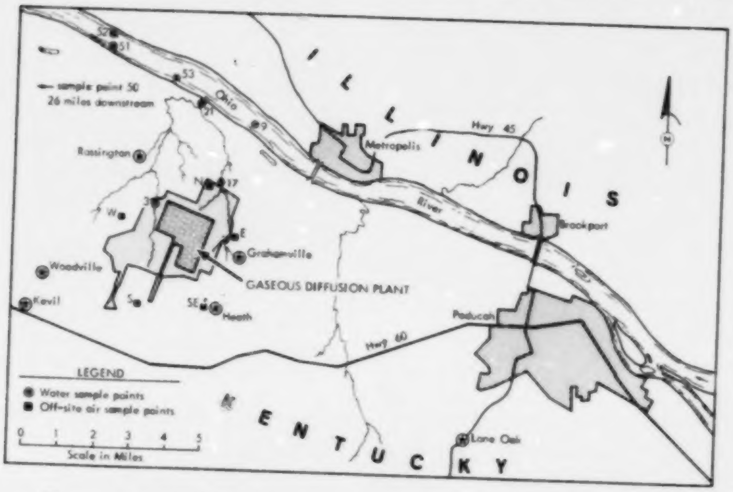

Figure 2. Sampling locations, Paducah Gaseous Diffusion Plant

Table 1. Uranium concentrations in outdoor air samples Paducah Plant, July–December 1970

Sample locations[a]	Number of samples	Uranium alpha radioactivity[b] (fCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	26	70	<20	20
East	26	410	<20	50
South	26	100	<20	10
West	26	170	<20	20
Summary	104	410	<20	20
About 1 mile outside plant perimeter fence:				
North	26	80	<20	20
East	26	100	<20	20
South	26	90	<20	10
West	26	60	<20	10
Southeast	26	70	<20	10
Summary	130	100	<20	10

[a] See figure 2.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/s.

[c] The minimum detectable concentration of uranium in air is 20 fCi/m³.

[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Table 2. Gross beta radioactivity in outdoor air samples Paducah Plant, July–December 1970

Sampling station[a]	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	26	7.2	<0.1	0.44
East	26	1.2	<.1	.29
South	26	.63	<.1	.16
West	26	.68	<.1	.19
Summary	104	7.2	<.1	.27
About 1 mile outside plant perimeter fence:				
North	26	.44	<.1	.18
East	26	.44	<.1	.18
South	26	.63	<.1	.18
West	26	.50	<.1	.18
Southeast	26	.43	<.1	.18
Summary	130	.63	<.1	.18

[a] See figure 2.

[b] The minimum detectable concentration of gross beta radioactivity in air is 0.1 pCi/m³.

[c] The AEC standard for immediate daughter products of uranium in air is 1 nCi/m³ (standard for thorium-234).

Table 3. Concentrations of uranium in water Paducah Plant, July–December 1970

Sample locations[a] and station number	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou 3	26	18	<1	4
Little Bayou 17	26	140	3	43
Mouth of Bayou Creeks 21	5	7	<1	2
Ohio River 9	5	2	<1	<1
Composite of 50, 51, 52, and 53	5	1	<1	<1

[a] See figure 2.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/s.

[c] The minimum detectable concentration of uranium in water is 1 pCi/liter.

[d] The AEC standard for natural uranium in water beyond a controlled area is 20 nCi/liter.

Table 4. Concentration of gross beta radioactivity in water, Paducah Plant, July–December 1970

Sample locations[a] and station number	Number of samples	Gross beta radioactivity (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou 3	26	600	<100	<100
Little Bayou 17	26	12,000	<100	700
Mouth of Bayou Creeks 21	5	<100	<100	<100
Ohio River 9	5	<100	<100	<100
Composite of 50, 51, 52, and 53	5	200	<100	<100

[a] See figure 2.

[b] The minimum detectable amount of gross beta radioactivity in water is 100 pCi/liter.

[c] The AEC standard for the immediate daughter products of uranium in water beyond a controlled area is 20 nCi/liter.

Table 5. External gamma radiation levels July–December 1970

Sample locations[a]	Number of readings	Average gamma radiation (μR/h)
At plant perimeter fence:		
North	5	20
East[b]	5	30
South	5	20
West	5	20
Summary	20	20
About 1 mile outside plant perimeter fence:		
North	5	20
East	5	20
South	5	20
West	5	20
Southeast	5	20
Summary	25	20

[a] See figure 2.

[b] Near uranium hexafluoride cylinder storage area.

taken at the mouth of the creeks reflects the dilution provided by overflow from the Tennessee Valley Authority ash pond; these analyses averaged 0.01 percent of the AEC standard. Uranium in the Ohio River was not significantly above the detection limit. Beta activity in these drainage streams was less than 0.5 percent of the AEC standard in Big Bayou, less than 5 percent of the AEC standard in Little Bayou, and averaged below the detection limit at the mouth of the creeks and in the Ohio River samples.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/h at all sampling stations for July-December 1970, except for the east plant perimeter station which had an average of 0.03 mR/h.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1969	September 1970
January-June 1970	March 1971

Reported Nuclear Detonations, March 1972

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on March 10, 1972. The signals originated from the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20-200 kilotons.

The Peoples Republic of China set off a nuclear explosion in the atmosphere at approximately 1 a.m., EST, March 18, 1972, at their Lop Nor nuclear test area in northwest China. The yield was in the range of 20–200 kilotons.

The United States recorded seismic signals on March 27, 1972, presumably from a Soviet underground nuclear explosion. The signals originated a few minutes before midnight, EST, March 27, 1972, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

There were no reported nuclear detonations for the United States for March 1972.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DISTRIBUTION OF CESIUM-137 AND NATURALLY OCCURRING RADIONUCLIDES IN SEDIMENTS OF LAKE MICHIGAN. *Phillip A. Plato. Radiation Data and Reports*, Vol. 13, April 1972, pp. 181–187.

Measurements of radioactivity in bottom sediments of Lake Michigan were made during 1969 and 1970. The only manmade radionuclide found was cesium-137 which originated from over two decades of atmospheric testing of nuclear weapons. A correlation was observed between accumulation of cesium-137 in sediments and water current patterns in Lake Michigan. Concentrations of naturally occurring potassium-40 and radium-226 were found to correlate with the type of sediment present.

KEYWORDS Cesium-137, Lake Michigan, potassium-40, radium-226, sediment, water.

RADIOACTIVITY LEVELS IN SELECTED OHIO STREAMS; THE GREAT MIAMI RIVER, THE LITTLE MIAMI RIVER, AND MILL CREEK; JUNE-AUGUST 1968. *Office of Water Programs, U.S. Environmental Protection Agency, Radiation Data and Reports*, Vol. 13, April 1972, pp. 189–194.

A water quality study of the Little Miami River, Great Miami River, and Mill Creek was conducted by the Office of Water Programs, U.S. Environmental Protection Agency. Analyses were performed for uranium, radium-226, lead-210, thorium and strontium-90. Uranium concentrations in the Little Miami River, Great Miami River, and Mill Creek averaged 0.4, 0.9, and 0.3 μg/liter, respectively. Radium-226 concentrations averaged 0.08, 0.11, and 0.04 pCi/liter, respectively. Strontium-90 concentrations averaged 0.7, 0.4, and 1.1 pCi/liter, respectively. The average thorium concentration was less than 3 μg/liter in all three streams. Lead-210 averaged less than 0.2 pCi/liter in the Little and Great Miami Rivers and 0.7 pCi/liter in Mill Creek.

KEYWORDS: Lead-210, Ohio, radionuclides, radium-226, rivers, strontium-90, surface water, thorium, uranium.

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RADIATION DATA AND REPORTS

Volume 13, Number 5, May 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Concentration Factors in the Aquatic Invironment [1]

Steven M. Jinks and Merril Eisenbud [2]

Concentration factors for various freshwater and marine organisms as gathered from the literature are presented. Attention is called to the existence of considerable variability in the reported values, and the reasons for this variability are briefly discussed. In addition to the difference in concentration factors for the marine and freshwater environments and because of differences in concentrations of stable elements in the two systems, other sources of variability include errors in sampling and analysis, physiological factors, and ecological disequilibria.

Critical pathway analysis of radioisotopes—recommended by the International Commission on Radiological Protection (ICRP) (*1*) — is finding increasing favor in the evaluation of environmental risks from power reactor operation. When one undertakes such an analysis, the concentration factors for aquatic organisms frequently have an important influence on estimates of the dose to be received by people living nearby.

The concentration factor for a given organism is defined as:

$$CF = \frac{C_o}{C_w} \quad \text{(at equilibrium)}$$

where:

CF = concentration factor

C_o = concentration of a given radionuclide or stable element in the organism, and

C_w = concentration of the radionuclide or stable element in the ambient water.

The requirement that C_w and C_o be in equilibrium with respect to each other is an essential but frequently overlooked part of the definition.

A review of the literature in which concentration factors are reported for the principal nuclides in fresh water and marine organisms indicates wide variability as shown in tables 1 and 2. The purpose of this paper is to make available these summarized data, to call attention to the existence of considerable variability in the reported values, and to discuss briefly the reasons for this variability.

There is, of course, general recognition that, because of the higher concentration of stable mineral elements in the marine environment, most concentration factors in fresh water are much higher than those in the marine environment (*34*). Thus, any presentation of the variability in the reported values should distinguish between these two types of aquatic systems.

The basic sources of variability in reported concentration factors consist of errors in sampling and analysis, physiological factors, and ecological disequilibria.

Analytical errors involve both the techniques of measurement and the method of expression of the concentration factor. Quantitation of radionuclide levels in environmental samples may yield widely variable results when analyses are conducted in different laboratories. For example, the International Atomic Energy Agency (IAEA), International Laboratory of Marine Radioactivity, has recently conducted an intercalibration study (*35*) which compared meas-

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[1] This investigation was supported in part by a Center grant from the National Institute of Environmental Health Sciences, Grant No. ES00260.

[2] S. M. Jinks and M. Eisenbud are on the staff of the Institute of Environmental Medicine, New York University Medical Center, 550 First Avenue, New York, N.Y.

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Table 1. Concentration factors for various classes of freshwater organisms

Nuclides	Group	Concentration factor range	Mean concentration factor[a]	Number of values included	References
Cesium	Plants	80–4,000	907	9	*(2–6)*
	Fish	120–22,000	3,680	15	*(3,4,7–11)*
Strontium	Plants	80–410	200	5	*(12–13)*
	Fish	0.85–[illegible]	14	13	*(12–17)*
Manganese	Plants	1,300–600,000	150,000	9	*(2, 10, 18–20)*
	Molluscs	1,100–1,600,000	~300,000	9	*(2, 20–22)*
	Crustacea	1,700–250,000	125,000	6	*(2, 11, 19, 21)*
	Fish	0.1–400	81	19	*(2,10, 11, 20, 21)*
Cobalt	Plants	300–30,000	6,760	11	*(2, 20, 23)*
	Molluscs	300–85,000	32,408	5	*(20, 23)*
	Fish	60–3,450	1,615	5	*(2, 20, 23)*
Zinc	Plants	140–15,000	3,155	13	*(10, 19, 20, 23)*
	Molluscs	30–140,000	33,544	5	*(20, 23)*
	Crustacea	300–4,000	1,800	3	*(11, 19, 23)*
	Fish	10–7,600	1,744	10	*(2, 10, 11, 20, 23)*
Iron	Plants	40–45,000	6,675	10	*(10, 19, 20, 23)*
	Molluscs	20–80,000	25,170	4	*(20, 23)*
	Crustacea	60–1,800	930	3	*(19, 23)*
	Fish	0.1–1,225	191	8	*(10, 20)*
Iodine	Plants	10–200	69	8	*(23, 25)*
	Molluscs	60–1,000	320	4	*(23, 25)*
	Fish	0.5–25	9	4	*(23–25)*
Cerium	Plants	200–35,000	3,180	12	*(11, 23, 25)*
	Molluscs	400–1,500	1,100	4	*(23, 25)*
	Crustacea	300–1,000	600	2	*(23)*
	Fish	2–160	81	2	*(23, 25)*
Potassium	Fish	340–18,000	4,400	6	*(11, 26, 27)*
Calcium	Plants	64–720	350	5	*(21)*
	Fish	0.5–470	70	18	*(11, 21)*

[a] The means are intended to provide a better indication of the distribution of these concentration factor values. They should not be considered as representing the "appropriate concentration factors" for application in environmental dosimetry for freshwater or marine environments.

urements by 44 different laboratories of certain radionuclides in sea water. The results show a wide range in the reported values. The ratios of minimum to maximum in the reported values for each nuclide varied from 3.5 for strontium-90 to 570 for zirconium-niobium-95. A previous intercalibration study conducted on an international scale has revealed a similar high degree of variability in stable element analysis by neutron activation and atomic absorption spectroscopy (*36*). The major sources of error in these types of analyses have not been identified, and it is quite likely that errors in analysis of biological materials would not parallel those found for water analysis at each laboratory. Thus, the calculated concentration factor may be significantly affected by error associated with the analytical measurements.

Of course, radionuclide concentrations in the various tissues of an organism may often be considerably different (e.g., strontium-90 in skeletal and soft tissues). This phenomenon could result in apparent large differences in reported concentration factors if no indication is given of which specific tissues were examined.

Calculation of the concentration factor on the basis of wet weight of the organism may also introduce substantial variability as has been pointed out by Fukai (*37*).

Another source of error originates from the practice of analyzing the stable elemental content of biota and then calculating the CF by using literature values for the elemental concentration of fresh water or sea water. This procedure allows one to make use of extensive tabulations of the elemental content of aquatic organisms and water appearing in the literature [e.g., Vinogradov, (*2*)]. However, since the concentration in each organism often is not being compared with the concentration in the body of water from which it came, these concentration factor values may be in error. Concentration factors calculated in this manner can be expected to have larger errors for the freshwater environment, where fluctuations in water concentrations of the elements are generally greater than in marine systems (*38*).

Several physiological factors can affect the concentration factor. These include species differences, age, and size, as well as reactions to

Table 2. Concentration factors for various classes of marine organisms

Nuclides	Group	Concentration factor range	Mean concentration factor[a]	Number of values included	References
Cesium	Plants	17–240	51	10	(*11, 28*)
	Molluscs	3–28	15	7	(*11, 23, 29*)
	Crustacea	0.5–26	18	5	(*11, 23*)
	Fish	5–244	48	10	(*11, 23*)
Strontium	Plants	0.2–82	21	15	(*11, 22, 30*)
	Molluscs	0.1–10	1.7	10	(*23, 30*)
	Crustacea	0.1–1.1	0.6	8	(*23, 30*)
	Fish	0.1–1.5	0.43	9	(*11, 23, 30*)
Manganese	Plants	2,000–20,000	5,230	10	(*21, 23, 30*)
	Molluscs	170–150,000	22,080	11	(*21, 23, 29, 30*)
	Crustacea	600–7,500	2,270	8	(*11, 23*)
	Fish	35–1,800	363	11	(*11, 23*)
Cobalt	Plants	60–1,400	553	5	(*11, 21, 22, 30*)
	Molluscs	1–210	166	6	(*23, 30*)
	Crustacea	300–4,000	1,700	3	(*23, 30, 31*)
	Fish	20–5,000	650	9	(*23, 30, 31*)
Zinc	Plants	80–2,500	900	4	(*11, 23, 30*)
	Molluscs	2,100–330,000	47,000	11	(*11, 23, 30, 32*)
	Crustacea	1,700–15,000	5,300	6	(*11, 23, 30*)
	Fish	280–15,500	3,400	12	(*11, 23, 30*)
Iron	Plants	300–6,000	2,260	7	(*11, 23, 29, 30*)
	Molluscs	1,000–13,000	7,600	6	(*23, 30*)
	Crustacea	1,000– 4,000	2,000	—	(*23, 30*)
	Fish	600–3,000	1,800	6	(*30*)
Iodine	Plants	30–6,800	1,065	8	(*21, 23, 29, 30*)
	Molluscs	20–20,000	5,010	4	(*23, 30*)
	Crustacea	20–48	31	4	(*23, 29, 30*)
	Fish	3–15	10	5	(*23, 30*)
Cerium	Plants	120–4,500	1,610	13	(*11, 23, 29*)
	Molluscs	100–350	240	3	(*23*)
	Crustacea	5–220	88	4	(*1, 23*)
	Fish	0.3–538	99	6	(*11, 23, 29*)
Potassium	Plants	4–31	13	10	(*11, 21, 29*)
	Molluscs	3.5–10	8	10	(*11, 21, 23, 29*)
	Crustacea	8–19	12	10	(*11, 21, 23, 29*)
	Fish	6.7–34	16	10	(*11, 23*)
Calcium	Plants	1.8–31	10	20	(*21, 23*)
	Molluscs	0.2–112	16.5	20	(*21, 23*)
	Crustacea	0.5–250	40	12	(*21, 23*)
	Fish	0.5–7.6	1.9	20	(*21, 23*)
Plutonium	Plants	—	1,000	1	(*23*)
	Molluscs	—	286	1	(*33*)
	Fish	0.1–5	2.6	2	(*23, 33*)
Rubidium	Plants	12–42	23	3	(*21*)
	Molluscs	11–27	17	3	(*23*)
	Crustacea	8.9–17.3	13	3	(*23*)
	Fish	7.6–23.8	17	6	(*23*)
Ruthenium	Plants	15–2,000	448	8	(*11, 23, 29*)
	Molluscs	1–3.6	2.2	3	(*23*)
	Crustacea	1–100	38	4	(*11, 23*)
	Fish	0.4–26	6.6	5	(*11, 23*)
Zirconium-niobium	Plants	170–2,900	1,119	12	(*11, 23, 28*)
	Molluscs	8–165	81	4	(*23*)
	Crustacea	1–100	51	4	(*11, 23*)
	Fish	0.05–247	86	5	(*11, 23*)

[a] The means are intended to provide a better indication of the distribution of these concentration factor values. They should not be considered as representing the "appropriate concentration factors" for application in environmental dosimetry for freshwater or marine environments.

changes in the temperature and chemical characteristics of the environment. In some cases, the tissue concentrations may be under homeostatic control, and therefore independent of the ambient concentration. This is known to be true for potassium and calcium, and may result in lower observed concentration factors for their chemical congeners, cesium and strontium, in systems high in the former elements (*7, 39, 40*). Homeostatic control may apply to other elements as well. For example, the tissue concentrations of manganese in Hudson River fish have been found to remain quite constant in spite of large variations in the manganese content of water (*41*). In addition, the specific chemical and physical state of the nuclide may be important.

The concentration factor with respect to water may be influenced by the pathway through which the nuclide reaches the organism. Concentration factors may be affected by differences in the quantity or types of food eaten, and the radionuclide burdens of the various food organisms may, in turn, be influenced by diurnal or seasonal factors. Recently, there has also been increased awareness that bottom sediments may act as a source of radionuclides to aquatic organisms (*8, 9, 26, 42*). Transfer from sediments to biota apparently may occur either directly by ingestion of sedimentary material, or indirectly through food chains dependent on sediments. In addition, under certain circumstances (e.g., salt water intrusion into estuaries) some nuclides deposited in sediments may be made available to biota through desorption into the water phase (*41*).

Short-term variations in the concentrations of stable elements or radionuclides in the environmental media may result in nonequilibrium conditions between organism and environment at the time of measurement. Thus, the concentration of a nuclide in water can be diluted rapidly by heavy rainfall, or conversely the concentration can increase suddenly. These increases or decreases in concentration will not be followed immediately by corresponding changes in the biota. Finally, as has been indicated many times, determination of concentration factors using tracers in the laboratory is also subject to possible errors due to the artificial conditions inherent in many laboratory studies of this kind.

It appears impossible to achieve simplistic concentration factors valid for a general environment because a definable general environment does not exist for long in nature. Therefore, the term "concentration factor" is incomplete when used without specific reference to an extensive description of the conditions under which it was determined. To extract it from this description is unprofitable, and to attempt to use it for different conditions is not valid. Until we have sufficient experience in detailed definition of concentration factors for radionuclides in environments of nuclear facilities, there appears to be no alternative to measuring the desired quantities for each facility.

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Technical Notes

Americium Contamination Incident in a New York State Health Department Laboratory

Robert P. Whalen and Sherwood Davies[1]

The Department's Division of Laboratories and Research at New Scotland Avenue, Albany, N.Y., under the direction of Dr. Donald V. Dean, maintains radiological sciences laboratories in support for the Department's radiological health program, which is administered by the Bureau of Radiological Health. Since June 1967, the Division's laboratory at 55 Russell Road in Albany has provided radiochemical analysis and low-level counting of samples of air, water, milk, and food. From 1963 to 1967, that laboratory functioned in rented space at 22 Colvin Avenue, Albany, N.Y.

In February 1970, extensive alpha contamination was discovered in the Russell Road laboratory. The investigation of the source of contamination in the Russell Road Laboratory brought the investigators, inevitably, back to the former Colvin Avenue premises.

The source of this contamination was so unlikely and unsuspected that only coincidence revealed its existence. Aside from routine uranium analysis, no work with alpha emitters had ever been performed at Russell Road. From 1962 to 1965, work with plutonium-239 had been carried out at the New Scotland Avenue laboratory and a electro-deposited disc had been counted at the Colvin Avenue laboratory. Routine and regular monitoring of the division's laboratory had not revealed the contamination—primarily because the emitter was an isotope not used in regular procedures and research at the laboratory.

On February 5, 1970, a small radium calibration standard sealed in a Tri-Carb liquid scintillation unit at the Russell Road laboratory was suspected of having ruptured. An alpha survey disclosed no contamination associated with this source, but did reveal extensive alpha contamination on chairs, desks, benches, file cabinents, and other appurtenances. This contamination was so gross that the investigators, headed by Dr. Joseph Sharp, Director of the Russell Road laboratory, decided that the contamination could not have emanated from the calibration source.

That weekend, Doctor Sharp and his team identified, isolated, packaged, and stored in a locked room at the laboratory, all contaminated materials which they found.

The pattern of the contamination found in certain books, particular areas of the laboratory, and in a sports jacket implicated one particular laboratory researcher (Mr. N), even though his assigned work in the laboratory only involved instrument repair, development, maintenance, and calibration. This researcher had been a full time employee of the laboratory since 1965 and had been a consultant since 1963.

Doctor Sharp visited Mr. N at his home on Sunday, February 8th. and discussed the problem with him. Subsequent examination of Mr. N's home with his consent, revealed contamination similar to that found in the laboratory. In the course of the investigation, Mr. N removed a small cardboard box containing a metallic object from a bureau drawer and turned the packet over to Doctor Sharp as well as the contents of the bureau drawer.

Both the box and the metallic object were found to emit alpha activity which subsequent isotopic analysis established as being primarily americium-241 with a small fraction of plutonium-239 as a casual impurity.

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[1] Dr. Whalen is Deputy Commissioner, New York State Department of Health, Albany, New York; Mr. Davies is Director, Bureau of Radiological Health, New York State Department of Health.

Americium-241 is an artificially prepared, silvery, radioactive metal with a physical half-life of 458 years (*1*) and a biological half-life of about 195 years in bone (*2*). Maximum permissible body burden for americium-241 in bone for a radiation worker is 50 nanocuries compared to 100 nanocuries for radium-226 and 40 nanocuries for plutonium-239 (*2*). Americium-241 has a 60 keV gamma energy with an external gamma dose rate of 0.039 mR/h at one meter per millicurie (*3*). Americium-241 is a daughter of plutonium-241 and the parent of neptunium-237. The nonoccupational maximum permissible concentration (MPC) in air is 2×10^{-13} μCi/cm^3 and in water, 9×10^{-5} μCi/cm^3. Inhalation represents the most likely source of exposure. The fraction of americium reaching the bone from ingestion is 2.5×10^{-5} and from inhalation 6.3×10^{-2} (*2*).

The metal slide in the box was contaminated with americium-241 from a primary source which Mr. N reported had been returned to the vendor. This source was located by the vendor and forwarded to the Atomic Energy Commission for analysis.

With the assistance of the U.S. Atomic Energy Commission, selected materials were sent to Idaho Operations Office for analysis:

1. metal slide from pillbox from Mr. N's residence.
2. Handbook of Chemistry and Physics from the Radiological Science Laboratory, and
3. the original source.

The metal slide was contaminated on both sides with the maximum activity on one side calculated to be about 49 μCi of americium-241. The handbook was contaminated with americium-241 estimated to be not more than 0.2 to 0.3 μCi.

The original source, consisting of a metal disc 1/16 inch thick by 1¼ inch in diameter, was calculated to have a source strength of 10 millicuries at the time of analysis. A circular shaded area was observed in the center of the disc similar to that produced by an electrodeposition cell. It is not known whether the source was prepared by electrodeposition, direct evaporation or by other means.

Plutonium-239 is a casual impurity remaining from the original preparation of americium-241, and neptunium-237 is the daughter product of radioactive decay of the americium-241, whose concentration relates directly to the age and concentration of americium-241. The ratios of americium-241 to plutonium-239 and plutonium-239 to neptunium-237 indicate that the contamination originated from a single source.

It might be noted here that a laboratory in New Jersey had been licensed by the Atomic Energy Commission in 1963 to possess an americium-241 plated foil source not to exceed 50 millicuries, with a total possession limit of 100 millicuries. Mr. N was an employee of the laboratory at that time and the license provided that the source be used by or under his supervision. This license expired in 1967.

Fixed and removable alpha activity of up to 100,000 cpm was found by scintillation and gas-flow alpha field survey equipment at the N home (table 1). The results of air samples taken with a Hi Vol sampler showed three times the MPC for a nonoccupational worker in the workshop and five times the MPC in the master bedroom (table 2). Mr. N agreed that he and members of his family would undergo whole body counting examinations. In addition

Table 1. Summary of selected survey results using scintillation and gas-flow alpha survey equipment in N residence, February 10, 1970

Survey	Direct reading in counts per minute[a]	Results of swipe analysis in counts per minute[b]	
Master bedroom:			
Closet floor	300-5,000		
Dresser drawer handle	2,000	150	
Shoes (soles)	400		
Dresser top	3,000	2,500	
Man's coat	12,000		
Suit	1,200		
Bathroom:			
Scale	70,000	100,000 10,000	two separate swipes
Daughter's bedroom:			
Chair	Background		
Desk	Background		
Bed	Background		
Ten-year old boy's bedroom:			
Desk	1,400	200	
Den:			
Bookcase shelf	600		
Family room:			
Dark brown briefcase	100,000	8,000	
Workshop:			
Bench	10,000	4,000	
Floor	2,000	2,500	

[a] PAC-1SAG—alpha scintillation equipment.
[b] PAC-3G—gas flow alpha survey meter.

Table 2. Air sampling results

Surveyed area	Americium-241 concentration in air (fCi/m³)
Soluble—maximum permissible concentration in air:	
Nonoccupational	200
Occupational	6,000
N residence:	
Prior to decontamination:	
Workshop	630
Master bedroom	1,010
During decontamination:	
Family room	990
Ten-year old son's room	90
Following decontamination:	
Family room	<.2
Upstairs hall	<.2
Upstairs hall with air conditioning equipment on	180
Family room with air conditioning equipment on	120
Health Department Laboratory:	
55 Russell Road Chemistry Laboratory during decontamination	27.7
22 Colvin Avenue during decontamination	20

to the N family, a number of others who were friends or close working associates, who might therefore have a possible body burden, were requested to participate in bioassay studies and whole body counting examinations. The Department summoned its radiological specialists from regional offices at Buffalo and White Plains to assist in the Albany investigation. The New York University Medical Center staff assisted with the whole body counting.

The preliminary report on the results of the whole body counting examinations indicated the following body burdens:

Mr. N, age 57	87 nanocuries
Son, age 10	93 nanocuries
Wife, age unknown	13 nanocuries
Son, age 20	11 nanocuries
Daughter, age 18	6.5 nanocuries

Recounts at New York University reported a body burden of 89 nanocuries for Mr. N and 40 nanocuries for the 10-year-old son, with a significant fraction of the americium-241 contained in the skeleton. Argonne National Laboratory reported body burdens of 65 nCi for Mr. N and 42 nCi for the 10-year-old son. The whole body counting results for all other persons involved were negative.

Twenty-four hour urine samples were collected from the N family and laboratory workers. One laboratory reported all urine results as negative, another laboratory showed elevated levels for Mr. N and his 10-year-old son of 4.92 and 2.93 dpm/sample respectively, and four laboratory personnel showed moderately elevated levels of approximately 1 dpm/sample.

The human exposure of Mr. N and his son was evidently chronic, occurring since 1963, 1964 or 1965. Findings to date indicated extensive contamination in Mr. N's private residence, the Russell Road low level counting laboratory, and measurable body burdens of americium-241 in Mr. N's family.

A parallel investigation conducted by the Bureau of Radiological Health revealed alpha contamination at the former department laboratory site on Colvin Avenue. The contamination was fixed to such an extent that decontamination efforts are still being conducted at that location (tables 3 and 4):

Table 3. Selected survey results using scintillation and gas-flow alpha survey equipment at 22 Colvin Avenue on February 11, 1970

Location	Direct reading in counts per minute[a]	Direct reading in counts per minute[b]	Results of swipe analysis in counts per minute[b]
Floor tile	700	750	
Floor tile	400	500	
Floor tile	200	250	
Floor tile under drinking fountain	700	......	Negative
Light switch	200	......	
Electric box	8,000	10,000	3,000
Outside door	400	700	100

[a] PAC—1 SAG
[b] PAC—3 G

Table 4. Selected survey results using FIDLER instrument at 22 Colvin Avenue on February 23, 1970

Location	Gross reading[a] (cpm)
A	2,000
B	500
C	500
D	12,000
E	1,500
F	10,000
G	30,000
H	40,000
I	2,500

[a] Readings at 1 inch from floor using HV-1 scale. Background-250 cpm. FIDLER field calibration with ^{241}Am source, HV-1 scale reading at contact 8.6 cpm approximately equivalent to 100 dpm/100 cm².

Health Department officials conferred with representatives of the Atomic Energy Commission and the U.S. Public Health Service to review the findings in the investigation and to arrange for additional assistance. The Department, on February 17th, requested the Atomic Energy Commission to provide assistance by a radiation contamination (RADCON) team. A four-man team from Ballistic Research Laboratories, Aberdeen Proving Ground, Md., arrived in Albany that night.

The team met with Health Department investigators for briefing sessions the next morning. The team's instrumentation included a field instrument for the detection of low energy radiation, known as a "FIDLER". This "FIDLER" proved extremely useful measuring the 60 keV gamma energy of americium-241. It consists of a thin ($^{1}/_{16}$ inch) 5-inch diameter NaI Harshaw crystal with an Eberline pulse rate meter. It was able to detect the 60 keV gamma radiation of americium-241 in rugs, mattresses, and tile that had not been detectable by conventional scintillation or gas-flow alpha survey instruments.

With the additional support provided by the RADCON team, investigative priorities were established including a resurvey of the N home, the school attended by N's younger son, a recreation center attended by the family, and parts of the Russell Road laboratory and former laboratory site on Colvin Avenue.

This resurvey verified the preliminary findings of the Health Department staff and located fixed activity not previously identified in rugs and under tiles.

The RADCON team proved of considerable assistance in defining the extent of the problem. The Public Health Service obtained three additional "FIDLERs" from the National Aeronautics and Space Administration for use in the survey. All suspected locations and areas where contamination might be thought to have occurred were monitored. In each such instance, the Department notified the property holder whether the findings were negative or positive. If positive, the notification included recommendations for corrective action.

Dr. Hollis S. Ingraham, the New York State Health Commissioner, issued an order on February 19th, prohibiting access or entry to the N family home to any person, except with the specific authorization of the Commissioner of Health. This included Mr. N and members of his family who took up temporary residence in a motel.

The Commissioner's action was designed to prevent a spread of contamination, and provide additional impetus for identifying and cleaning up contaminated areas in and on the N premises.

Another order by Commissioner Ingraham required that Mr. N submit to him an acceptable and detailed plan for:

A. the reduction of levels of alpha contamination in the house so as not to exceed the following limits in the interest of health and safety:
   fixed contamination: average 500 dpm/100 cm^2; maximum 2,500 dpm/100 cm^2; removable contamination: 100 dpm/100 cm^2;

B. the protection of personnel carrying out decontamination procedures;

C. the techniques to be employed in measuring levels of radioactivity;

D. the types of packaging and disposal to be used for contaminated removable, disposable items;

E. the prevention of offsite contamination, and

F. the identification of individuals and corporations proposed to be engaged pursuant to the plan, including training, experience and licenses held.

Close associates of the N family, who ate and slept in the home with any frequency, were investigated if there was a strong likelihood that they might have inhaled or ingested radioactive dust.

Two maids had lived in the N household during the period since 1963. One, who had lived in the N home while the family was in New Jersey, was easily located in that State. The other maid, who had lived in the New Jersey home and the Albany residence occupied by the N family, had since returned to her native Germany. Whole body counting of the New Jersey maid showed a low (7 nCi) but measurable body burden, and the German authorities reported that the maid living in Germany was found to have a negative whole-body count.

A cat in the N household became sick and died during the investigation. The preliminary report on the body burden of the cat shows approximately 2.5 nCi. Additional studies are planned.

Mr. N contracted with Applied Health Physics of Pittsburgh, Pa., to decontaminate his residence. This was done under a license issued on April 10, 1970, by the Bureau of Radiological Health. Bureau staff closely observed the decontamination. After a final survey, the Commissioner's order prohibiting access to the home was lifted in May 1970.

All premises or likely locations where contamination occurred were resurveyed with the FIDLER. Fixed activity in the floor at 22 Colvin Avenue was verified. Hi Vol air sample results for americium-241 were below permissible limits. The premises are presently being decontaminated. Contamination was also found in two other private residences in Albany, N.Y. The moving van that had transferred Mr. N's belongings from New Jersey to Albany, N.Y. sometime in 1965 was found and surveyed. Contaminated materials in the private residences have been removed and packaged for ground burial (table 5).

Nine private residences, a recreational center, a public school, a college dorm room and an apartment were carefully surveyed with the FIDLER and no contamination found.

It was concluded by department investigators that the contamination in the Colvin Avenue laboratory and in the furniture and equipment moved from Colvin Avenue to the Russell Road laboratory was transported by Mr. N to the laboratory on his person, his clothing and other of his personal belongings and books.

The investigation may be summarized briefly even though it is continuing.

The Department has engaged Dr. Neil Wald of Pittsburgh, an internationally recognized expert on americium radiation as a consultant to assist with the continuing medical investigation indicated as a result of the whole body counting.

Mr. N's home has been decontaminated and the family lives there. Mr. N has left the health department.

All identified sources of americium contamination revealed by this investigation have been decontaminated, with the exception of some fixed activity in the floor of a truck and the former laboratory site at Colvin Avenue. The fixed activity located is yielding, but stubbornly, to continuing decontamination efforts.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, BUREAU OF RADIOLOGICAL HEALTH. Radiological Health Handbook, Revised Edition 1970. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1970).

(*2*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation (1959). Health Phys 3:1–380 (1960).

(*3*) WANG, YEN, Editor. Handbook of Radioactive Nuclides (1969). The Chemical Rubber Company, Publisher, Cleveland, Ohio.

Table 5. Locations, equipment and premises surveyed for americium contamination and action initiated

Contamination identified	Location	Action
Health Department for low level counting laboratory	55 Russell Road, Albany, N.Y.	All contaminated equipment, supplies, and materials packaged and shipped for burial.
N residence	Albany, N.Y.	Premises decontaminated in accordance with order of Commissioner of Health.
Laboratory space leased by Health Department 1963–1967	22 Colvin Avenue, Albany, N.Y.	Premises decontaminated.
Temporary residence of N	Albany, N.Y.	Contaminated carpet and tiles removed and packaged for ground burial.
Household items transferred from N temporary residence to another location	Albany, N.Y.	Contaminated rugs, mattress, lampshades and cushions packaged for ground burial.
Truck transferring household belongings of N in 1965 from New Jersey to Albany, N.Y.		Truck decontaminated except for fixed radioactive contamination in "one spot" on floor of trailer.

SECTION I. MILK AND FOOD

Milk Surveillance, January 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports.* Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostron-

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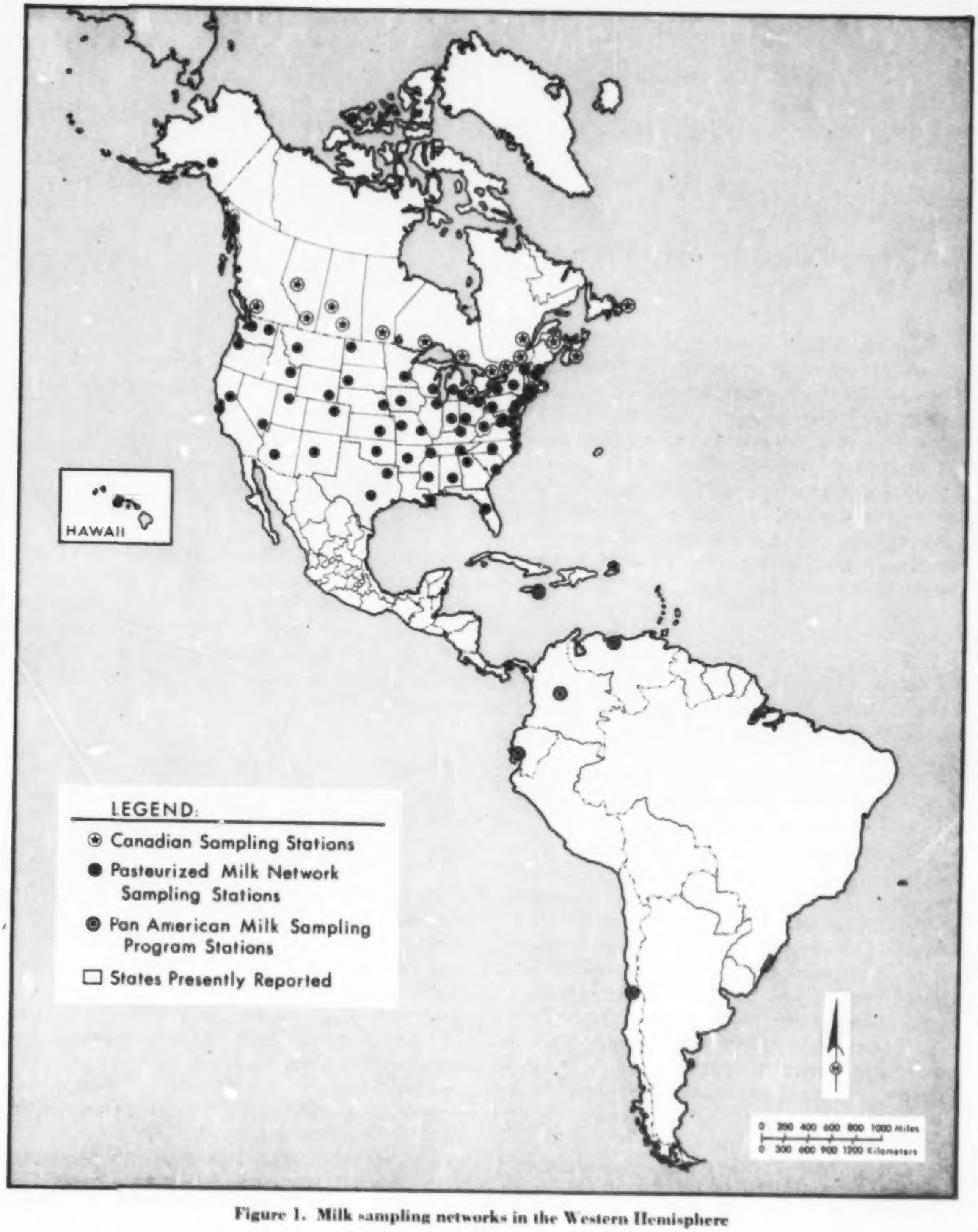
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

tium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.61 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971, with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the experiment.

The accuracy results of this experiment for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of all radionuclides from those of previous studies. Some improvement is still needed on the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data

Table 1. Distribution of mean results in milk quality control experiment

Isotope and known concentration $\pm 2\sigma$	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Iodine-131 (69 ±6 pCi/liter)	13 (100%)	0	0	13
Cesium-137 (52 ±6 pCi/liter)	12 (92%)	1 (8%)	0	13
Strontium-89 (31 ±6 pCi/liter)	9 (90%)	1 (10%)	0	10
Strontium-90 (41.6 ±2.4 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environment levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviation)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council

Table 2. Concentrations of radionuclides in milk for January 1972 and 12-month period February 1971 through January 1972

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	8	7	0	11
Alaska:	Palmer[c]	P	6	5	0	12
Ariz:	Phoenix[c]	P	0	0	0	0
Ark:	Little Rock[c]	P	12	12	0	14
Calif:	Sacramento[c]	P	0	1	0	0
	San Francisco[c]	P	3	4	0	0
	Del Norte	P	9	13	16	11
	Fresno	P	0	2	12	4
	Humboldt	P	NA	3	NA	5
	Los Angeles	P	2	2	11	3
	Mendocino	P	10	6	9	8
	Sacramento	P	2	3	11	4
	San Diego	P	0	1	3	3
	Santa Clara	P	0	2	18	6
	Shasta	P	3	3	7	6
	Sonoma	P	2	3	10	6
Colo:	Denver[c]	P	5 (2)	5	15 (2)	8
	East	R	([d])		≈0	≈0
	Northeast	R	([d])		≈0	≈0
	Northwest	R	([d])		NS	≈0
	South Central	R	([d])		NS	
	Southeast	R	([d])		≈0 (2)	≈0
	Southwest	R	([d])		≈0 (3)	2
	West	R	([d])		NS	≈0
Conn:	Hartford[c]	P	6	7	17	8
	Central	P	7		18	
Del:	Wilmington[c]	P	6	8	13	5
D.C:	Washington[c]	P	9	8	12	9
Fla:	Tampa[c]	P	4	5	30	43
	Central	R	8		18	42
	North	R	6		38	25
	Northeast	R	6		29	34
	Southeast	R	NA		69	54
	Tampa Bay area	P	7		33	42
	West	R	9		14	19
Ga:	Atlanta[c]	P	10	10	13	16
Hawaii:	Honolulu[c]	P	4	3	0	2
Idaho:	Idaho Falls[c]	P	6	5	0	2
Ill:	Chicago[c]	P	5	6	11	10
Ind:	Indianapolis[c]	P	7	7	0	4
	Central	P	6	8	15	12
	Northeast	P	5	8	15	15
	Northwest	P	8	9	15	15
	Southeast	P	8	9	10	14
	Southwest	P	8	9	0	15
Iowa:	Des Moines[c]	P	6	6	0	2
	Iowa City	P	6	7	0	11
	Des Moines	P	5	6	9 (4)	11
	Little Cedar	P	7	7	10	12
	Spencer	P	NS	6	NS	9
Kans:	Wichita[c]	P	9	8	0	2
	Coffeyville	P	8	8	15	15
	Dodge City	P	6	6	12	9
	Falls City, Nebr	R	NS		NS	
	Hays	P	5	10	0	9
	Kansas City	P	8	8	16	14
	Topeka	P	6	9	15	11
	Wichita	P	6	10	0	11
Ky:	Louisville[c]	P	7	8	13	5
La:	New Orleans[c]	P	14	14	0	17
Maine:	Portland[c]	P	7	8	21	19
Md:	Baltimore[c]	P	7	8	0	6
Mass:	Boston[c]	P	7	8	11	12
Mich:	Detroit[c]	P	5	7	16	10
	Grand Rapids[c]	P	9	9	15	9
	Bay City	P	9	7	15	15
	Charlevoix	P	14	10	12	16
	Detroit	P	8	7	14	9
	Grand Rapids	P	7	7	0	11
	Lansing	P	8	8	19	16
	Marquette	P	10	10	23	24
	Monroe	P	5	4	0	4
	South Haven	P	7	6	3	9
Minn:	Minneapolis[c]	P	8	8	25	15
	Bemidji	P	6	9	21	19
	Duluth	P	13	17	21	28
	Fergus Falls	P	8	8	15	21
	Little Falls	P	16	17	23	30
	Mankato	P	5	6	0	11
	Minneapolis	P	17	16	16	17

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for January 1972 and 12-month period February1971 through January 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued						
Minn:	Rochester	P	10	9	15	14
	Worthington	P	7	6	17	0
Miss:	Jackson[c]	P	11	13	0	10
Mo:	Kansas City[c]	P	5	8	0	7
	St. Louis[c]	P	6	5	19	5
Mont:	Helena[c]	P	5	6	12	10
Nebr:	Omaha[c]	P	7	7	0	4
Nev:	Las Vegas[c]	P	0 (2)	2	0 (2)	1
N.H:	Manchester[c]	P	8	8	21	19
N.J:	Trenton[c]	P	6	8	0	8
N. Mex:	Albuquerque[c]	P	0	2	0	0
N.Y:	Buffalo[c]	P	6	7	0	8
	New York City[c]	P	7	8	14	11
	Syracuse[c]	P	8	7	13	9
	Albany	P	5	6	[e]0 (6)	[e]0
	Buffalo	P	6	0	[e]0 (2)	[e]0
	Massena	P	NA		[e]0	[e]0
	New York City	P	9	8	[e]0	[e]0
	Syracuse	P	9	4	[e]0	[e]0
N.C:	Charlotte[c]	P	8	10	11	12
N. Dak:	Minot[c]	P	9	9	14	14
Ohio:	Cincinnati[c]	P	6	6	0	1
	Cleveland[c]	P	7	7	11	6
Okla:	Oklahoma City[c]	P	6	6	0	10
Oreg:	Portland[c]	P	6	5	0	5
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		TA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia[c]	P	NS	8	NS	6
	Pittsburgh[c]	P	9	10	0	7
	Dauphin	P	6	8	12	12
	Erie	P	7	8	14	17
	Philadelphia	P	5	7	0	14
	Pittsburgh	P	1	7	16	14
R.I:	Providence[c]	P	6	8	0	14
S.C:	Charleston[c]	P	8	9	16	14
S. Dak:	Rapid City[c]	P	8	6	13	7
Tenn:	Chattanooga[c]	P	6	8	5	10
	Memphis[c]	P	6	7	0	8
	Chattanooga	P	NA	9	10	14
	Clinton	R	NA	9	14	14
	Fayetteville	R	NA	10	8 (2)	7
	Knoxville	P	NA	7	10 (2)	10
	Nashville	P	NA	7	0	10
	Kingston	R	NA	7	8 (2)	9
	Lawrenceburg	R	NA	5	14	6
	Pulaski	R	NA	8	7	4
Tex:	Austin[c]	P	1 (2)	2	0 (2)	0
	Dallas[c]	P	3	6	0	4
	Amarillo	R	NS	3	NS	0
	Corpus Christi	R	NS	5	NS	0
	El Paso	R	NS	3	NS	0
	Forth Worth	R	3	4	0	0
	Harlingen	R	NS	4	NS	0
	Houston	R	6	8	0	8
	Lubbock	R	NS	3	NS	0
	Midland	R	3	3	0	0
	San Antonio	R	NS	5	NS	0
	Texarkana	R	NS	NS	NS	NS
	Tyler	R	NS	13	NS	11
	Wichita Falls	R	NS	8	NS	4
Utah:	Salt Lake City[c]	P	4 (2)	5	7 (2)	11
Vt:	Burlington[c]	P	5	6	12	10
Va:	Norfolk[c]	P	6	8	14	5
Wash:	Seattle[c]	P	3	5	14	6
	Spokane[c]	P	5	6	0	6
	Benton County	R	5	2	0	0
	Franklin County	R	NS	3	NS	5
	Sandpoint, Idaho	R	12	12	19	22
	Skagit County	R	4	8	0	11
W. Va:	Charleston[c]	P	8	8	0	7
Wisc:	Milwaukee[c]	P	6	6	12	7
Wyo:	Laramie[c]	P	4 (2)	4	0 (2)	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for January 1972 and 12-month period February 1971 through January 1972—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		NA	
Edmonton	P	NA		NA	
British Columbia: Vancouver	P	NA		NA	
Manitoba: Winnipeg	P	NA		NA	
New Brunswick: Fredericton	P	NA		NA	
Newfoundland: St. John's	P	NA		NA	
Nova Scotia: Halifax	P		NA	NA	
Ontario: Ottawa	P		NA	NA	
Sault Ste. Marie	P		NA	NA	
Thunder Bay	P		NA	NA	
Toronto	P		NA	NA	
Windsor	P		NA	NA	
Quebec: Montreal	P		NA	NA	
Quebec	P		NA	NA	
Saskatchewan: Regina	P		NA	NA	
Saskatoon	P		NA	NA	
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal [c]	P	0	0	0	5
Colombia: Bogota	P	0	1	0	0
Chile: Santiago	P	0	0	0	2
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Kingston	P	7	5	24	72
Puerto Rico: San Juan [e]	P	3	4	0	11
Venezuela: Caracas	P	0	0	0	0
PMN network average [f]		6	7	7	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131:	Colorado—25 pCi/liter	Cesium-137:	Colorado—25 pCi/liter	Strontium-90:	New York—3 pCi/liter
	Michigan—14 pCi/liter		New York—20 pCi/liter		
	Oregon—15 pCi/liter		Oregon—15 pCi/liter		

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [e].

NA, no analysis.

for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average

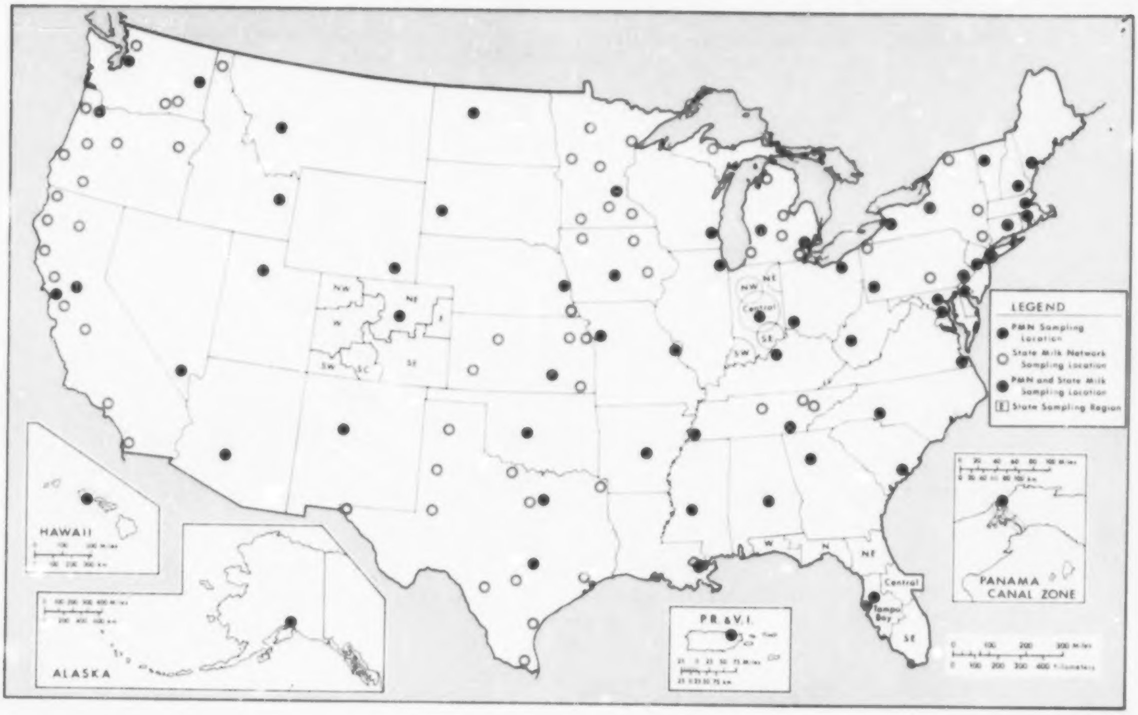
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
NW
NE
W
SW
SC
SE
Central
HAWAII
ALASKA
P.R.& V.I.
PANAMA CANAL ZONE
Tampa Bay

Figure 2. State and PMN sampling stations in the United States

for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, and cesium-137 for January 1972 and the 12-month period, February 1971 to January 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for January 1972 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 and iodine-131 were detected.

Table 3. Strontium-89 and iodine-131 in milk
January 1972

Sampling location		Strontium-89 (pCi/liter)	Iodine-131[a] (pCi/liter)
Calif:	Del Norte (State)	9	
	Mendocino (State)	17	
Colo:	Denver (PMN)		[b] 44 (2)
	East (State)		26 (2)
	Northeast (State)		38 (6)
Kans:	Dodge City (State)		17
	Wichita (State)		20
La:	New Orleans (PMN)	6	
Tenn:	Fayetteville (State)		18 (2)
Utah:	Salt Lake City (PMN)		20 (2)
Wyo:	Laramie (PMN)		39 (2)

[a] Attributed to atmospheric nuclear detonation by the Peoples Republic of China on January 7, 1972.
[b] Number in parentheses indicates number of samples.

Strontium-90 monthly averages ranged from 0 to 17 pCi/liter in the United States for January 1972, and the highest 12-month average was 17 pCi/liter (Duluth and Little Falls, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 69 pCi/liter in the United States for January 1972, and the highest 12-month average was 54 pCi/liter (Southeast Florida), representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as folows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Connecticut Standard Diet	January-December 1970	December 1971
Institutional Total Diet	July-September 1971	April 1972
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

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Carbon-14 in Total Diet and Milk, July-December 1971

Office of Radiation Programs
Environmental Protection Agency

In July 1965, a program to determine the levels of carbon-14 and tritium in the total diet and milk in the United States was initiated by the Public Health Service. In December 1970, this program was transferred to the Office of Radiation Programs of the Environmental Protection Agency (EPA). Initially, monthly samples from each of the EPA Institutional Total Diet Sampling Network (ITDSN) and Pasteurized Milk Network (PMN) stations were composited and analyzed according to six arbitrarily selected regions: Northeast, South, Delta, Central, Southwest, and Northwest. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

In January 1966, the program was modified to include selected stations in each of the previously mentioned regions plus Alaska and Hawaii. The nine geographically distributed sampling stations are: Palmer, Alaska; Honolulu, Hawaii; Idaho Falls, Idaho; Chicago, Ill; New Orleans, La; Boston, Mass; Portland, Oreg; and Charleston, S.C. Los Angeles, Calif. is not a PMN station, but a special milk sample is collected for purposes of comparison with the routine ITDSN sample.

A 1-liter milk sample and a 2-kilogram food sample are sent to the Northeastern Radiological Health Laboratory for analysis. The milk and total diet samples analyzed represent the samples collected for that month.

The carbon-14 analyses are performed semiannually. The tritium analyses were discontinued in July 1969 because the results were

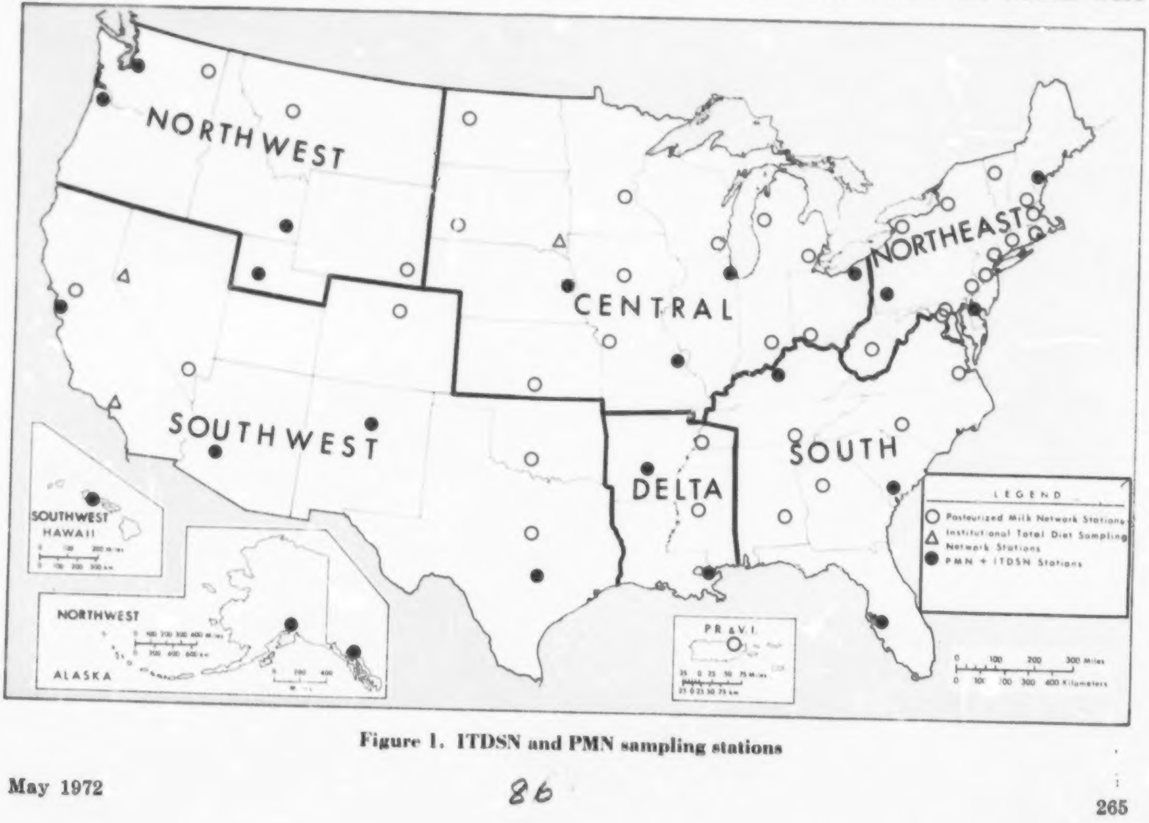
NORTHWEST
CENTRAL
NORTHEAST
SOUTHWEST
SOUTH
DELTA
SOUTHWEST
HAWAII
NORTHWEST
ALASKA
PR & V.I.
LEGEND
○ Pasteurized Milk Network Stations
△ Institutional Total Diet Sampling Network Stations
● PMN + ITDSN Stations
0 100 200 300 Miles

Figure 1. ITDSN and PMN sampling stations

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only slightly above the limit of detectability and were less than 1 percent of the maximum permissible concentration for milk and food consumed by the general population.

Analytical procedures

The carbon-14 content is determined by combustion of the milk or food sample and collection and purification of the evolved carbon dioxide. The carbon dioxide is then converted to methane and counted in a gas-proportional counter (*1*).

Results and discussion

The carbon-14 concentration in food and milk was measured as dpm of carbon-14 per gram of carbon and converted to pCi/kg or pCi/liter by using the percent carbon in the sample. The carbon content in food ranged from 8.2 to 11.7 percent with an average of 9.7 percent, and the carbon content in milk ranged from 4.4 to 6.0 percent with an average of 5.3 percent. Table 1 shows the dpm per gram of carbon and the carbon-14 concentrations in total diet and milk for July-December 1971.

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Other coverage in *Radiological Health Data and Reports:*

Period	Issue
January 1969–June 1970	January 1971
July–December 1970	May 1971
January–June 1971	December 1971

Table 1. Carbon-14 in total diet and milk, July-December 1971

Location		Date collected (1971)	Total diet		Milk	
			(dpm/g C $\pm 2\sigma$)	(pCi/kg $\pm 2\sigma$)	(dpm/g C $\pm 2\sigma$)	(pCi/liter $\pm 2\sigma$)
Alaska:	Palmer	October	15.35 ±0.28	670 ±10	16.75 ±0.30	410 ±10
Calif:	Los Angeles	October	16.76 ± .30	730 ±10	15.51 ± .44	380 ±10
Hawaii:	Honolulu	October	17.72 ± .31	770 ±10	15.86 ± .30	390 ±10
Idaho:	Idaho Falls	October	18.27 ± .46	800 ±20	15.95 ± .44	390 ±10
Ill:	Chicago	October	17.17 ± .30	750 ±10	17.14 ± .44	420 ±10
La:	New Orleans	October	18.16 ± .44	790 ±20	16.42 ± .28	400 ±10
Mass:	Boston	October	17.30 ± .26	760 ±10	15.41 ± .28	380 ±10
Oreg:	Portland	October	17.64 ± .31	770 ±10	15.13 ± .44	370 ±10
S.C:	Charleston	October	16.62 ± .38	730 ±20	14.50 ± .42	360 ±10
Average			17.22	750	15.85	390

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1969	October 1971
Colorado River Basin	1968	March 1972
Gross Radioactivity in Surface Waters of the United States	August 1971	April 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, HASL	January-June 1971	April 1972
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	July-September 1971	April 1972
Washington	July 1969-June 1970	March 1972

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Gross Radioactivity In Surface Waters of The United States September 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for the month of October 1968 (April 1969 issue). With the publication of data for January 1971, it is intended to reinitiate this activity as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from 24 rivers during September 1971. Table 2 presents the gross alpha and beta radioactivity results on composited samples from six rivers collected and composited during the third quarter of the 1971 water year (April-June 1971). The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

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(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

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Table 1. Gross radioactivity in U.S. surface waters, September 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
Animas River:									
Durango, Colo.	1	<0.2		<1		1		<4	
Allegheny River:									
Pittsburgh, Pa. (8 miles)[b]	[c]1	<.2		1		3		4	
Pittsburgh, Pa. (5 miles)[b]	[c]1	<.2		1		3		10	
Big Sandy River:									
Wayne County, W. Va.	[c]1	1		< .7		5		8	
Big Sioux River:									
Sioux Falls, S. Dak.	[c]1	<.2		<2		<5		28	
Cheyenne River:									
Edgemont, S. Dak.	[c]7	<.3		14		1		35	
Clinch River:									
Kingston, Tenn.	[d]4	<.2	(.1—.3)	.5	(.3—.8)	<1.8	(.5—<3.0)	4	(2—7)
Colorado River:									
Silt, Colo	[a]1	<.2		<3		1		8	
De Beque, Colo.	[c]7	1		2		1		6	
Utah-Colorado State Line	[a]7	4		5		14		12	
Moab, Utah (above Mill Creek)	[d]3	7	(4—9)	11.3	(10—12)	25	(5—39)	37.7	(30—53)
Moab, Utah (below Highway Bridge)	[d]5	1.7	(1—3)	6	(4—7)	9	(7—11)	18.7	(13—26)
Cuyahoga River:									
Cleveland, Ohio	[c]1	2		11		3		19	
Dolores River:									
Bedrock, Colo	[d]5	<3.8	(<.2—14)	14.8	(6—23)	12.0	(4—35)	27.2	(15—42)
Gateway, Colo.	[d]5	<3.6	(1—8)	15.6	(7—19)	12.8	(3—32)	57.4	(38—81)
Great Lakes:									
Lake Erie Buffalo, N.Y.	[c]1	2		<3		<3		8	
Guyandotte River:									
Guyandotte, W. Va.	[c]1	1		1		7		5	
Kanawha River:									
Winfield Dam, W. Va	[c]1	1		1		7		7	
Mason County, W. Va.	[c]1	<.2		<.2		<3		4	
Maumee River:									
Toledo, Ohio	[c]1	<2		<6		<3		<8	
Mississippi River:									
Burlington, Iowa	[c]1	1		1		7		11	
Missouri River:									
Yankton, S. Dak.	[c]1	<2		3		5		14	
Omaha, Nebr.	[c]1	1		4		3		18	
St. Joseph, Mo.	[c]1	2		3		7		24	
St. Louis, Mo.	[c]1	3		1		12		13	
Monongahela River:									
Pittsburgh, Pa. (4.5 miles)[b]	[c]1	<.2		1		3		.	
Pittsburgh, Pa. (8 miles)[b]	[c]1	<.2		1		3		5	
Muskingum River:									
Lock and Dam No. 2	[c]1	<.2		<.5		3		4	
North Platte River:									
Henry, Nebr.	[c]1	<.2		12		<1		30	
Ohio River:									
New Martinsville, W. Va	[c]1	<.2		1		3		8	
Marietta, Ohio	[c]1	2		1		7		4	
Old Lock No. 19, W. Va.	[c]1	<.2		1		3		4	
Addison, Ohio	[c]1	<.2		1		3		4	
Kyger Creek, W. Va.	[c]1	1		1		3		4	
Gallipolis, Dam, W. Va.	[c]1	<.2		1		3		4	
Boyd County, Ky.	[c]1	<.2		<.2		3		6	
Cincinnati, Ohio	[d]5	1.5	(<.2—3.2)	1	(1—1)	5.6	(4—8)	9	(8—12)
Warwood, W. Va.	[c]1	<.2		1		3		8	
Hancock, W. Va.	[c]1	1		1		3		8	
Platte River:									
Plattsmouth, Nebr.	[c]1	2		4		21		21	
Roanoke River:									
John Kerr Dam, Va.	[d]4	<.6	(<.2—8)	<.6	(<.2—2)	3	(3—4)	6.7	(5—11)
St. Lawrence River:									
Massena, N.Y.	[d]2	<.2	(<.2—<.2)	<.5	(<.4—.5)	<2.5	(<1—4)	7	(7—7)
San Miguel River:									
Naturita, Colo.	[d]5	<.2	(<.2—1)	2.0	(1—3)	<2.8	(<1—6)	7.4	(6—9)
Uravan, Colo. (above)	[d]5	<.8	(<.2—2)	3.4	(2—4)	[illegible]	(2—4)	11.4	(4—18)
Uravan, Colo. (below)	[d]5	3.8	(<.2—6)	17.2	(3—29)	20.4	(3—63)	37.6	(16—48)
Susquehanna River									
Conowingo, Md.	[d]3	<.2	(<.2—<.2)	<.2	(<.2—<.2)	2.7	(1—5)	4.3	(<1—6)

[a] Indicates single grab sample.
[b] Distance from mouth of river.
[c] Indicates composite sample for fourth quarter ending in September 1971 of the 1971 water year.
[d] Where more than one sample is analyzed during the month, the minimum and maximum are in parentheses.

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Table 2. Gross radioactivity in U.S. surface waters, April-June 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Arkansas River:					
Ponca City, Okla	[a]1	8	6	13	8
Mississippi River:					
West Memphis, Ark	[a]1	3	2	7	6
Vicksburg, Miss	[a]1	9	2	25	6
Red River:					
Dennison, Tex	[a]1	2	3	3	4
Rio Grande:					
Laredo, Tex	[a]1	4	3	7	4
Brownsville, Tex	[a]1	3	42	4	45
Sabine River:					
Ruliff, Tex	[a]1	2	2	6	5
Verdigris River:					
Nowata, Okla	[a]1	2	3	4	4

[a] Indicates a composite sample for third quarter ending in June 1971 of the 1971 water year.

Radioactivity In New York State Surface Water, July-December 1970, And January-June 1971

Bureau of Radiological Pollution Control
New York State Department
of Environmental Conservation

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations.

Analytical procedures

Analysis of samples was performed by the Radiological Sciences Laboratory of the New York State Department of Health. The procedures described below were used to perform the indicated analyses.

A gross beta determination is made on a measured quantity of water, usually 250 ml. The sample residue is analyzed for its gross beta component in an end window, gas-flow proportional counter.

Strontium and alkaline earths are precipitated as carbonates from a 500 ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is percepitated as a chromate. Strontium is finally precipitated as a sulfate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1-2*). Strontium-90 is determined by yttrium-90 counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a flow proportional counter. Strontium-89 is estimated by taking the difference between the total radiostrontium and the strontium-90 radioactivity. Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Tritium in water is determined by liquid scintillation counting. The sample is vacuum

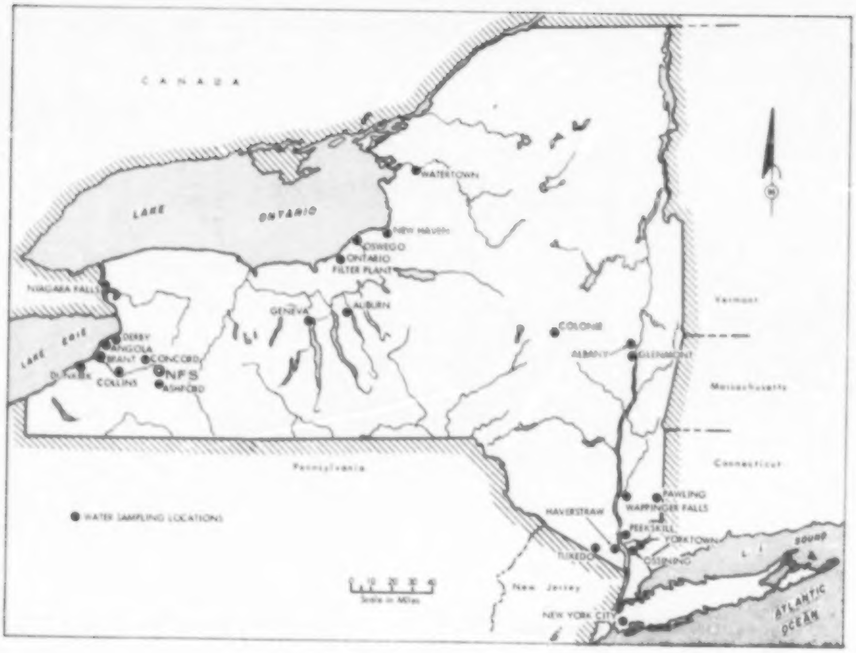
CANADA
LAKE ONTARIO
LAKE ERIE
WATERTOWN
NEW HAVEN
OSWEGO
ONTARIO FILTER PLANT
NIAGARA FALLS
GENEVA
AUBURN
DERBY
ANGOLA
BRANT
CONCORD
DUNKIRK
COLLINS
NFS
ASHFORD
COLONIE
ALBANY
GLENMONT
Vermont
Massachusetts
Connecticut
Pennsylvania
PAWLING
WAPPINGER FALLS
HAVERSTRAW
PEEKSKILL
YORKTOWN
TUXEDO
OSSINING
New Jersey
NEW YORK CITY
L. I. SOUND
ATLANTIC OCEAN
● WATER SAMPLING LOCATIONS
Scale in Miles
N

Figure 1. New York water sampling locations

Table 1. Gross beta radioactivity in New York raw surface water, July-December 1970 [a]

Location	Gross beta radioactivity (pCi/liter)							
	July-September 1970				October-December 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	1	2	ND	3	2	2	2
Ashford (Buttermilk Creek at Fox Valley Road)	3	3	3	2	3	5	8	3
(Buttermilk Creek at Thomas Corners Road)[b]	13	3,010	5,870	1,550	13	788	2,120	152
(Cattaraugus Creek at Bigelow Bridge)	3	3	4	3	3	6	8	4
Brant (Cattaraugus Creek at Irving)	13	213	1,280	71	13	47	84	22
Collins (Cattaraugus Creek at Gowanda)	13	164	334	70	13	76	195	21
Colonie (Filtration Plant)	13	5	6	4	10	4	5	3
Concord (Cattaraugus Creek at Springville Dam):								
Weekly composite sample	13	353	681	171	13	134	214	81
Daily continuous sample	62	352	1,590	97	61	143	378	39
Derby (Sturgeon Point)	3	6	10	4	3	4	5	4
Geneva (Seneca Lake	2	4	4	4	3	4	6	3
Glenmont (Hudson River)	12	4	6	3	12	3	4	2
Haverstraw (Iona Filtration Gallery)	NS				1	5		
New Haven (Demster Beach Road)	2	6	8	5	1	4		
New York City	5	3	4	2	3	3	4	2
Niagara Falls (West Branch Niagara River)	3	5	6	4	4	4	5	3
Ontario Filter Plant	3	4	5	3	2	4	5	4
Ossining (Indian Brook Reservoir)	3	6	7	5	3	8	9	7
(Hudson River at Sing Sing)	13	47	68	28	12	30	54	6
Oswego	3	5	5	4	3	4	5	4
Pawling (Pond at United Nuclear)	14	4	6	3	4	4	7	3
Peekskill (Camp Field Water Supply)	3	4	5	3	4	5	7	3
(Hudson River at Standard Brands)	13	26	37	10	11	15	30	4
Rhinecliff (Hudson River)	14	3	4	ND	9	3	5	2
Tuxedo (Indian Kill)	3	5	7	2	3	4	6	3
Wappinger (Hudson River)	14	4	6	3	9	4	5	3
Watertown (Black River)	3	4	5	3	3	4	4	3
Yorktown (Croton Reservoir)	4	4	4	4	3	4	4	3

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
NS, no sample collected.
ND, nondetectable.

Table 2. Strontium-90 concentration in New York surface waters, July-December 1970

Location	Strontium-90 (pCi/liter)							
	July-September 1970				October-December 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Thomas Corners Road)[a]	14	1,120	2,010	609	13	247	799	70
(Cattaraugus Creek at Bigelow Bridge)	3	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
Brant (Cattaraugus Creek at Irving)	12	47	119	32	13	15	38	5
Collins (Cattaraugus Creek at Gowanda)	11	49	86	14	13	18	48	ND
Concord (Cattaraugus Creek at Springville Dam):								
Weekly composite sample	13	107	215	59	13	39	74	18
Daily continuous sample	6	189	291	131	NS			
Derby (Sturgeon Point Station)	3	ND	ND	ND	3	ND	ND	ND
Peekskill (Hudson River at Standard Brands)	13	ND	ND	ND	11	ND	ND	ND
(Hudson River at Sing Sing)	13	ND	ND	ND	12	ND	ND	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.
NS, no sample collected.

Table 3. Gross beta radioactivity in New York raw surface waters,[a] January-June 1971

Location	Gross beta radioactivity (pCi/liter)							
	January-March 1971				April-June 1971			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	2	2	2	3	2	3	2
(Colonie Filtration Plant)	13	5	11	2	13	4	5	3
Angola (Water Treatment Plant)	5	6	7	4	13	7	11	4
Ashford (Buttermilk Creek at Fox Valley Road)	3	4	6	2	3	2	3	ND
(Buttermilk Creek at Thomas Corners)[b]	13	1,010	1,330	639	13	1,420	5,370	100
Cattaraugus Creek at Bigelow Bridge)	3	5	9	3	3	3	5	ND
Brant (Cattaraugus Creek at Irving)	13	64	191	37	13	58	149	16
(Cattaraugus Creek at Gowanda)	13	80	236	39	13	65	144	12
Concord (Cattaraugus Creek at Springville Dam):								
Weekly composite sample	13	138	197	76	13	121	201	55
Daily continuous sample	59	134	289	47	65	211	343	17
Derby (Sturgeon Point Station)	7	4	5	3	13	6	15	3
Dunkirk (Filtration Plant)	6	4	5	2	12	3	4	2
Geneva (Seneca Lake)	3	3	4	3	3	4	4	4
Glenmont (Hudson River)	11	3	5	2	13	5	8	4
New Haven (Demster Beach)	NS				2	5	5	4
New York City	6	3	4	2	4	4	4	3
Niagara Falls (West Branch Niagara River)	3	4	4	3	2	4	4	4
Ontario (Water Filtration Plant)	7	4	5	3	13	4	6	2
Ossining:								
(Hudson River at Sing-Sing)	14	16	53	ND	13	10	36	ND
(Indian Brook Reservoir—raw)	3	5	6		3	8	12	6
(Indian Brook Reservoir—treated)	NS				3	4	7	3
Oswego	6	4	4	3	5	4	4	3
Pawling (Pond at United Nuclear)	3	6	11	3	2	5	6	4
Peekskill:								
(Hudson River at Standard Brands)	14	5	13	ND	13	3	12	ND
(Camp Field Water Supply—raw)	3	3		ND	3	6	10	4
(Camp Field Water Supply—treated)	NS				3	3	4	3
Rhinecliff (Hudson River)	11	3	5	2	6	4	4	3
Tuxedo (Indian Kill)	3	6	8	4	1	5		
(Indian Kill—below Reservoir)	NS				3	4	7	2
Wappinger (Hudson River)	11	3	5	2	6	4	5	3
Watertown (Black River)	3	3	5	2	3	4	5	4
West Haverstraw (Iona Filtration Gallery)	1	11	—	—	NS			
Yorktown (Croton Reservoir)	3	2	4	ND	3	3	5	ND
(Croton Reservoir—Deep Well)	NS				3	3	4	2

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.
NS, no sample.

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distilled and an aliquot mixed with a scintillation cocktail (either 15 ml of Aquasol and 6 ml of distillate or 17 ml of a dioxane-base cocktail and 3 ml of distillate). Samples are counted for 50 minutes in either a Packard Tri-Carb model 3315 or a Beckman LS200B liquid scintillation spectrometer. Minimum sensitivities are 1,000 pCi/liter for the Tri-Carb and 500 pCi/liter for the Beckman.

Discussions and results

During the July-September 1970 period, six daily samples and two weekly samples were collected from site 042, Cattaraugus Creek at Springville Dam and one sample from site 065, Cattaraugus Creek at Irving, were over 600 pCi/liter of gross beta which is considered to be the allowable AEC limit without making a specific isotopic analysis.

Specific isotopic analyses were made on each of the samples and the concentrations of major isotopes present were determined. The most important isotope present in all of the samples was strontium-90.

The AEC was notified of the increasing incidence of samples over 600 pCi/liter and additional treatment controls have been implemented by Nuclear Fuels Services to reduce the concentration of strontium-90 until the proposed low level waste treatment facility is operational.

The number of samples, quarterly average, maximum and minimum gross beta-particle concentrations in New York surface water for July-December 1970 are given in table 1. Strontium-90 in surface water is shown in table 2.

During the October-December 1970 period, the concentrations of radionuclides in most waters throughout the State were low except for the waters immediately below the Nuclear Fuels Services discharge. The levels of radioactivity measured in Cattaraugus Creek were below AEC limits. There were no samples that exceeded the limit of 600 pCi/liter which would require a specific isotopic analysis to ascertain compliance with the AEC limits.

Gross beta-particle concentrations for January-June 1971 are given in table 3; strontium-90 concentrations are given in table 4.

Tritium concentration values for July 1970-June 1971 are given in tables 5 and 6. Tritium, the radioactive isotope of hydrogen, and a very low-energy beta-particle emitter, is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks reflected contributions to the streams from the Nuclear Fuels Services reprocessing plant.

REFERENCES

(1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Anal Chem 33:1356 (1961).

(2) WELFORD, G. and D. SUTTON, a paper presented at the American Chemical Society meeting in New York City, September 1960.

Table 4. Strontium-90 concentration in New York surface waters, January-June 1971

Location	Strontium-90 (pCi/liter)							
	January-March 1971				April-June 1971			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Thomas Corners)[a]	13	239	383	64	13	596	1,840	48
(Cattaraugus Creek at Bigelow Bridge)	2	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
Angola (Treatment Plant)	1	ND	—	—	NS	—	—	—
Brant (Cattaraugus Creek at Irving)	13	13	19	ND	13	20	44	ND
(Cattaraugus Creek at Gowanda)	13	17	34	8	13	29	90	ND
Concord (Springville Power Dam on Cattaraugus Creek)	13	30	43	16	13	50	137	7
Derby (Sturgeon Point)	2	ND	ND	ND	NS	—	—	—
Dunkirk (Filtration Plant)	1	ND	—	—	NS	—	—	—
Hudson River at Standard Brands	14	ND	ND	ND	11	ND	ND	ND
Hudson River at Sing-Sing	14	ND	ND	ND	13	ND	ND	ND

[a] This station is in the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.
NS, no sample.

Table 5. Tritium concentration of New York surface waters, July-December 1970

Location	Tritium concentration (nCi/liter)							
	July-September 1970				October-December 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	ND	1.7	ND	3	ND	1.1	ND
(Colonie Filtration Plant)	13	ND	1.6	ND	10	ND	1.5	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	2.4	ND
(Buttermilk Creek at Thomas Corners Road)[a]	13	364	1,190	28.0	13	33.8	140	1.3
(Cattaraugus Creek at Bigelow Bridge)	3	ND	1.3	ND	3	ND	ND	ND
Brant (Cattaraugus Creek at Irving)	13	13.7	35.7	1.6	13	2.2	8.3	ND
Collins (Cattaraugus Creek at Gowanda)	13	17.6	41.1	1.9	13	2.2	10.6	ND
Concord (Cattaraugus Creek at Springville Dam): Weekly composite sample	13	31.4	65.8	7.1	13	6.1	18.7	ND
Daily continuous sample	63	31.1	104	2.0	61	6.9	30.5	ND
Derby (Sturgeon Point Station)	3	ND	1.3	ND	3	ND	1.1	ND
Oswego (City Hall Tap)	3	ND	ND	ND	NS			
Pawling (Pond at United Nuclear)	14	ND	ND	ND	NS			
Rhinecliff (Hudson River)	14	ND	1.3	ND	9	ND	ND	ND
Wappinger (Hudson River)	14	ND	ND	ND	9	ND	ND	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
[b] Daily continuous sample taken.
ND, nondetectable.
NS, no sample.

Table 6. Tritium concentrations of New York surface waters, January-June 1971

Location	Tritium concentration (nCi/liter)							
	January-March 1971				April-June 1971			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	ND	ND	ND	2	ND	ND	ND
Angola (Water Treatment Plant)	5	ND	ND	ND	13	ND	1.4	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Thomas Corners Road)[a]	13	118	300	17.5	13	134	701	1.5
(Cattaraugus Creek at Bigelow Bridge)	3	ND	1.2	ND	3	ND	ND	ND
Brant (Cattaraugus Creek at Irving)	13	6.5	13.2	1.1	13	3.9	13.6	ND
(Cattaraugus Creek at Gowanda)	13	6.8	15.8	ND	13	5.2	25.0	ND
Colonie (Filtration Plant)	13	ND	ND	ND	11	ND	ND	ND
Concord (Cattaraugus Creek at Springville Dam): Weekly composite sample	13	16.2	32.1	3.4	13	11.2	45.1	1.4
Daily continuous sample	59	15.6	63.1	ND	65	11.2	68.3	ND
Derby (Sturgeon Point)	7	ND	ND	ND	13	ND	1.3	ND
Dunkirk (Filtration Plant)	6	ND	1.4	ND	12	ND	ND	ND
New Haven (Demster Beach)	NS				2	ND	ND	ND
Ontario (Water Filtration Plant)	6	ND	1.0	ND	13	ND	ND	ND
Oswego (City Hall tap)	6	ND	ND	ND	5	ND	ND	ND
Rhinecliff (Hudson River)	11	ND	ND	ND	6	ND	ND	ND
Wappinger (Hudson River)	11	ND	ND	ND	6	ND	ND	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.
NS, no sample collected.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1969	June 1970
January–June 1970	September 1971

Interstate Carrier Drinking Water Analysis Program, 1971

Office of Water Programs and
Office of Radiation Programs
Environmental Protection Agency

The routine surveillance of finished drinking water from public drinking water supplies is a project of the Office of Water Programs of the Environmental Protection Agency (EPA), in partial fulfillment of the requirements as set forth in Subpart J of the Interstate Quarantine Regulation (*1*) most commonly known as the Public Health Service Drinking Water Standards. The basic network for this activity consists of approximately 658 water supplies (serving over half of the U.S. population with access to public water systems) which provide water for use by interstate carriers. Laboratory support is provided by the Northeastern Radiological Health Laboratory, Eastern Environmental Radiation Laboratory, and Western Environmental Research Laboratory. All samples were taken as single grab samples and the results of the radiological analyses are shown in table 1. In many cases where a water system receives raw water from more than one source, the finished drinking water derived from each source has been examined.

The drinking water standards for radionuclides are conservative in their requirements so that the total intake of these nuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*).

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium-226 or 10 pCi/liter of strontium-90. In the absence of strontium-90, and in the absence of alpha emitters, the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance for control action recommended by the Federal Radiation Council. When mixtures of radionuclides are present, the relative contribution of each radionuclide to the total intake of the individual should be considered when evaluating the exposure.

REFERENCES

(*1*) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Federal Register Rules and Regulations, Title 42, Public Health Chapter 1, Part 72, Interstate Quarantine, Subpart J Drinking Water Standards: 2154–2155 (March 6, 1962).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Table 1. Radiological analysis of interstate carrier water supplies, 1971 [a]

Sample location		Date collected (1971)	Gross alpha radioactivity (pCi/liter ±2σ)	Gross beta radioactivity (pCi/liter ±2σ)	Radium-226 (pCi/liter ±2σ)	Strontium-90 (pCi/liter ±2σ)
Ala:	Oak Grove	7/20	0	6 ±1		
Alaska:	Ketchikan	10/7	0	3 ±1		
Del:	Yorklyn	7/22	0	7 ±1		
Ga:	Savannah	6/9	0	2 ±1		
		6/10	0	0		
		6/21	0	0		
		6/11	0	0		
		6/11	0	4 ±1		
		6/22	0	5 ±1		
		6/11	0	3 ±1		
		6/29	0	0		
		6/10	0	0		
Ill:	Lemont	4/29	5 ±2	23 ±6	3.0 ±0.2	0
	Mt. Vernon	9/24	0	6 ±3		
Ind:	Evansville	8/24	0	4 ±1		
	Gary	10/26	0	3 ±1		
	Michigan City	10/27	0	3 ±1		
	Middlebury	10/29	0	0		
Ky:	Catlettsburg	7/7	0	4 ±1		
	Covington	8/25	0	5 ±2		
	Fulton	8/25	0	0		
	Lexington	8/11	0	5 ±1		
		8/23	0	3 ±1		
	Louisville	9/6	0	6 ±1		
Mass:	Templeton	10/7	0	0		
		10/7	0	0		
Mich:	Elberta	6/22	0	0		
	Kalamazoo	11/3	0	2 ±1		
	Ludington	6/22	0	5 ±1		
	Owosso	11/4	0	4 ±3		
	St. Joseph	11/2	0	2 ±1		
Minn:	Campbell	4/21	0	9 ±2		
	Donnelly	4/22	7 ±2	11 ±2	.3 ±.1	0
	Graceville	4/20	0	4 ±2		
	Herman	4/22	0	10 ±2		
Miss:	Gulfport	7/21	0	0		
		7/21	0	3 ±1		
		7/21	0	0		
		7/21	0	0		
		7/21	0	3 ±1		
		7/21	0	0		
Mo:	Cape Girardeau	2/10	3 ±2	13 ±2		0
	Hermann	2/9	0	5 ±2		
	Kansas City	6/24	0	10 ±2		
	North Kansas City	3/26	0	5 ±2		
N. J:	Elizabeth	11/22	0	3 ±2		
	Greenwich	4/1	0	4 ±3		
	Merchantville	5/4	0	6 ±1		
	Paulsboro	3/31	0	6 ±1		
	Perth Amboy	7/10	0	3 ±1		
	Woodbridge	11/9	0	4 ±1		
N. Y:	Hudson	9/8	0	3 ±1		
	Peekskill	6/17	0	4 ±1		
	Rome	8/10	0	3 ±1		
	Utica	7/28	0	6 ±1		
N. Dak:	Cogswell	4/20	0	14 ±2	.3 ±.1	0
	Drayton	5/12	0	9 ±2		
	Fargo	5/11	0	5 ±2		
	Forman	4/20	0	14 ±2		0
	Gwinner	4/20	5 ±2	8 ±2		
Ohio:	Conneaut	6/29	0	5 ±1		
	Fairport Harbor	6/29	0	5 ±1		
	Marietta	5/26	0	5 ±4		
	Portsmouth	5/26	0	5 ±4		
	Youngstown	7/1	0	0		
S. Dak:	Britton	4/22	0	14 ±2		0
Vt:	Rutland	10/29	0	0		
	White River Junction	10/28	0	0		
Wash:	Longview	9/16	0	4 ±1		
Wisc:	Manitowoc	4/23	0	3 ±2		
	New Lisbon	8/17	0	0		
	Sturgeon Bay	6/21	0	0		
Summary			0.3	4.3	1.2	0

[a] The minimum detectable radioactivity is 2 pCi/liter for strontium-90, gross alpha, and gross beta radioactivity; and 0.1 pCi/liter for radium-226. All values equal to or less than the minimal detectable radioactivity are reported as zero.

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
1967-1969	December 1970
1970	July 1971

Tritium Surveillance System, October-December 1971

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the tritium in surface water network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for the period, January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for July-December 1969, have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

In the Tritium Surveillance System, drinking water samples were taken at 70 RAN stations, precipitation samples were collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and surface waters were sampled quarterly at 39 stations (figure 2). The specific locations for the surface water sampling system were determined by examining the

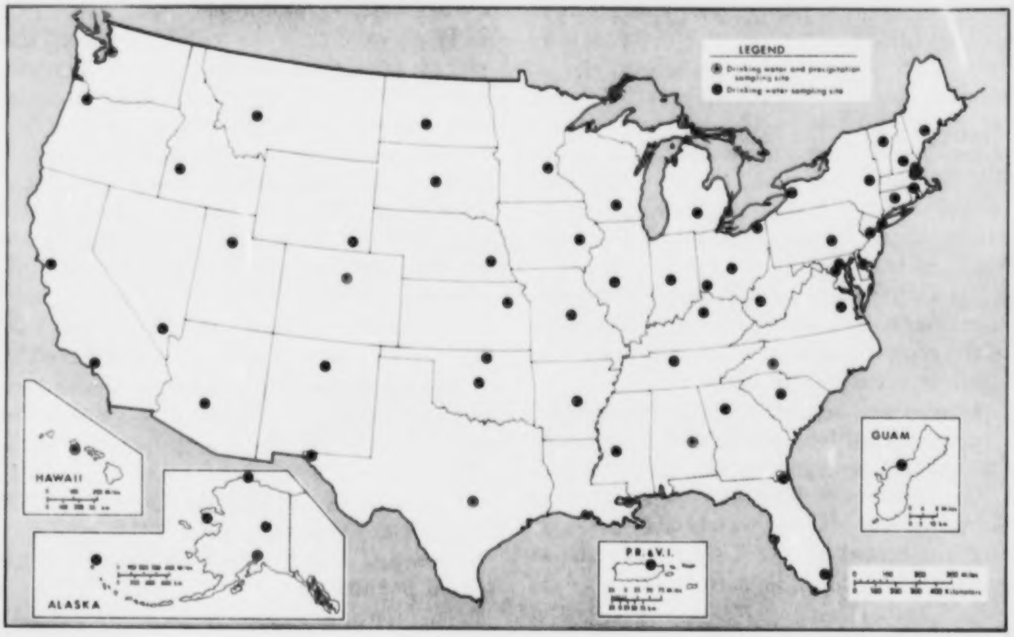
LEGEND
Drinking water and precipitation sampling site
Drinking water sampling site
HAWAII
ALASKA
GUAM
PR & V.I.

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

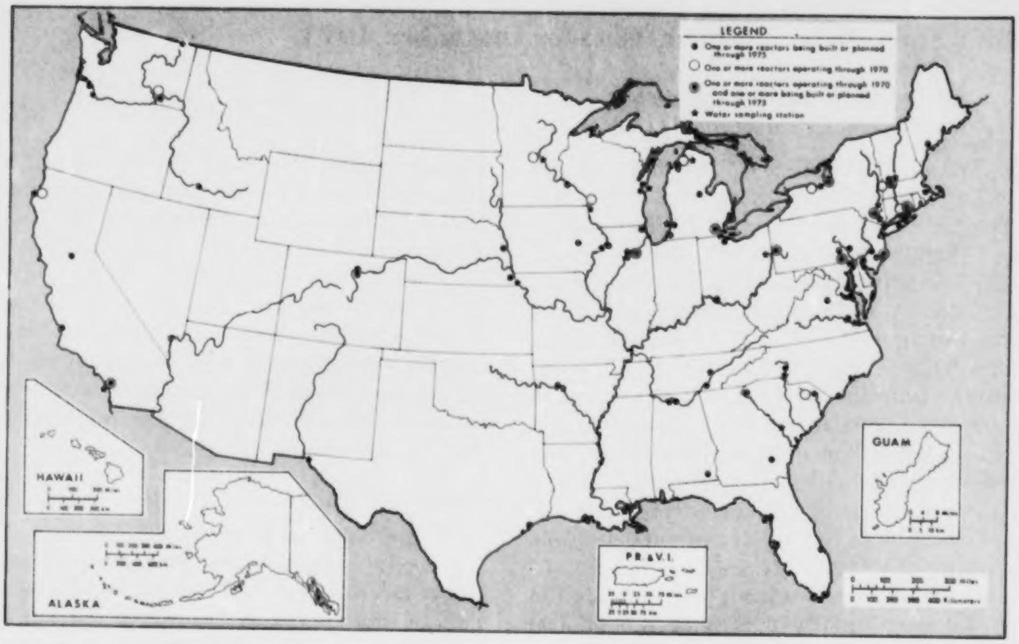
LEGEND
● One or more reactors being built or planned through 1975
○ One or more reactors operating through 1970
◉ One or more reactors operating through 1970 and one or more being built or planned through 1975
★ Water sampling station
HAWAII
ALASKA
GUAM
PR & V.I.

Figure 2. Surface water sampling locations for tritium surveillance system

water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quartery basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to one of our laboratories for analysis. Due to the different sensitivity of procedures used by the three laboratories, the minimum detectable concentration varies. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for October-December 1971. The average tritium concentration was 0.3 nCi/liter.

The radiation dose resulting from the observed tritium concentrations in the drinking water may be evaluated by using the relationship derived by Moghissi and Porter (*3*) from recommendations of the International Commission on Radiological Units and Measurements (*4*). Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.4 nCi/liter during the fourth quarter. This corresponds to a dose of 0.2 mrem/a, or less than 0.2 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 5.2 nCi/liter for the

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Table 1. Tritium concentration in tap water (RAN stations), October-December 1971

Location		Date collected (1971)	Tritum concentration (nCi/liter ±2σ)
Ala:	Montgomery	10/15	0.3 ±0.2
Alaska:	Anchorage	10/4	.6 ± .4
	Attu Island	10/11	0
	Fairbanks	10/10	0
	Juneau	11/4	0
	Kodiak	10/10	0
	Nome	10/9	.7 ± .4
	Point Barrow	10/7	.6 ± .4
Ariz:	Phoenix	10/4	0
Ark:	Little Rock	10/8	[a]0
Calif:	Berkeley	10/4	.5 ± .4
	Los Angeles	10/4	0
C.Z:	Ancon	10/26	[a]0
Colo:	Denver	10/13	.9 ± .4
Conn:	Hartford	10/6	0
Del:	Dover	10/8	0
D.C:	Washington	10/8	.3 ± .2
Fla:	Jacksonville	10/7	[a]0
	Miami	10/4	[a]0
Ga:	Atlanta	10/7	.3 ± .2
Guam:	Agana	10/5	0
Hawaii:	Honolulu	10/4	0
Idaho	Boise	10/14	.5 ± .4
Ill:	Springfield	10/18	0
Ind:	Indianapolis	11/8	0
Iowa:	Iowa City	10/5	.9 ± .4
Kans:	Topeka	10/12	0
Ky:	Frankfort	10/7	.4 ± .2
La:	New Orleans	10/7	.5 ± .2
Maine:	Augusta	10/4	0
Md:	Baltimore	10/4	.3 ± .2
Mass:	Lawrence	10/4	.5 ± .4
	Winchester	10/1	0
Mich:	Lansing	11/8	0
Minn:	Minneapolis	10/5	.9 ± .4
Miss:	Jackson	10/4	[a]0
Mo:	Jefferson City	10/8	0
Mont:	Helena	10/4	.4 ± .4
Nebr:	Lincoln	10/7	.4 ± .4
Nev:	Las Vegas	10/1	1.2 ± .4
N.H:	Concord	10/6	0
N.J:	Trenton	10/5	0
N. Mex:	Santa Fe	10/5	.8 ± .4
N.Y:	Albany	10/4	0
	Buffalo	10/5	.5 ± .4
	New York	10/12	0
N.C:	Gastonia	10/6	.3 ± .2
N. Dak:	Bismarck	10/5	1.4 ± .4
Ohio:	Cincinnati	10/26	0
	Columbus	10/6	.5 ± .4
	Painesville	11/8	.5 ± .4
Okla:	Oklahoma City	10/4	.3 ± .2
	Ponca City	10/7	.3 ± .2
Oreg:	Portland	11/4	0
Pa:	Harrisburg	10/8	0
P.R:	San Juan	10/8	[a]0
R.I:	Providence	10/12	0
S.C:	Columbia	10/7	.3 ± .2
S. Dak:	Pierre	10/4	1.2 ± .4
Tenn:	Nashville	10/7	.4 ± .2
Tex:	Austin	10/4	[a]0
	El Paso	10/4	[a]0
Utah:	Salt Lake City	10/4	0
Vt:	Barre	10/4	0
Va:	Richmond	10/8	[a]0
Wash:	Seattle	10/7	0
	Spokane	10/4	0
W. Va:	Charleston	10/5	.4 ± .2
Wisc:	Madison	10/8	0
Wyo:	Cheyenne	11/8	.5 ± .4
Average[b]			0.3

[a] The minimum detection limit for these samples was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

fourth quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.9 mrem/a or 0.5 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

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Table 2. Tritium concentration in surface water, October-December 1971

Location		Water source	Facility	Collection date (1971)	Concentration (nCi/liter ±2σ)
Ala:	Decatur	Tennessee River	Browns Ferry	10/29	0.4 ±0.2
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	10/14	[a]0
Calif:	Eureka	Humboldt Bay	Humboldt Bay	10/1	.8 ± .4
	San Onofre	Pacific Ocean	San Onofre	[b]9/28	0
Colo:	Greely	South Platte River	Fort St. Vrain	10/12	1.1 ± .4
Conn:	East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	10/27	1.1 ± .4
	Waterford	Long Island Sound	Millstone	10/27	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	10/6	[a]0
	Homestead	Biscayne Bay	Turkey Point	10/19	[a]0
Idaho:	Buhl	Snake River	National Reactor Testing Station	10/18	0
Ill:	Moline	Mississippi River	Quad-Cities	10/20	.5 ± .4
	Morris	Illinois River	Dresden and Argonne	10/21	0
La:	New Orleans	Mississippi River	(Several)	10/5	.5 ± .2
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	10/6	0
	Lusby	Chesapeake Bay	Calvert Cliffs	11/9	0
Mass:	Rowe	Deerfield River	Yankee	10/8	3.1 ± .4
Mich:	Charlevoix	Lake Michigan	Big Rock Point	11/15	0
	Monroe	Lake Erie	Enrico Fermi	11/15	0
	South Haven	Lake Michigan	Palisades	11/14	0
Minn:	Monticello	Mississippi River	Monticello	10/5	.9 ± .4
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	10/6	.8 ± .4
Nev:	Boulder City	Colorado River	Background	10/5	1.1 ± .4
N.J:	Bayside	Delaware River	Salem	10/19	0
N.Y:	Ossining	Hudson River	Indian Point	10/8	0
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	10/5	.5 ± .4
	Poughkeepsie	Hudson River	Background	10/6	0
N.C:	Charlotte	Catawba River	Wm. B. McGuire	10/22	.4 ± .2
Oreg:	Westport	Columbia River	Rainier and Hanford	12/3	.4 ± .4
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	10/6	5.2 ± .3
	Hartsville	Lake Robinson	H. B. Robinson	10/4	.5 ± .2
Tenn:	Kingston	Clinch River	Oak Ridge	NS	
Tex:	El Paso	Rio Grande	Los Alamos	12/16	0
Vt:	Vernon	Connecticut River	Vermont Yankee	10/4	.5 ± .4
Va:	Newport News	James River	Surry	10/13	.3 ± .2
Wash:	Northport	Columbia River	Background	10/5	1.2 ± .4
	Pasco	Columbia River	Hanford	10/6	.6 ± .4
W. Va:	Wheeling	Ohio River	Shippingport	10/7	.5 ± .4
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	10/13	.9 ± .4
	Victory	Mississippi River	LaCrosse and Prairie Island	10/3	0
Average[c]					0.6

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] Sample collected 3 days early.

[c] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

NS, no sample.

Table 3. Tritium concentration in precipitation from RAN stations, October-December 1971

Location		Tritium concentration[a] (nCi/liter ±2σ)		
		October	November	December
Ala:	Montgomery	0.3 ±0.2	0.6 ±0.2	0
Alaska:	Anchorage	0	NS	0
Colo:	Denver	.3 ± .2	0	.3 ± .2
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	0	0
N.C:	Gastonia	0	0	.4 ± .2
Tex:	Austin	0	0	0
Wash:	Seattle	0	NS	0

[a] The minimum detection limit for these samples was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero.

NS, no sample.

REFERENCES

(1) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January–June 1970. Radiol Health Data Rep 11: 638–639 (November 1970).

(2) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN) July–December 1969. Radiol Health Data Rep 11: 354–355 (July 1970).

(3) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(4) INTERNATIONAL COMMISSION ON RADIOLOGICAL UNITS AND MEASUREMENTS. Recommendations of the International Commission of Radiological Units and Measurements, National Bureau of Standards Handbook 85 (1964).

Other coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1970	May 1971
January–March 1971	July 1971
April–June 1971	November 1971
July–September 1971	April 1972

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Plutonium in Airborne Particulates	July-September 1971	April 1972
Surface Air Sampling Program 80th Meridian Network, *HASL*	January-December 1969	February 1972

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1. Radiation Alert Network
January 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during January 1972.

The following five stations had high readings in January: Denver, Colo., 28 pCi/m^3; Santa Fe, N. Mex., 21 pCi/m^3; Austin, Tex., 27 pCi/m^3; Salt Lake City, Utah, 25 pCi/m^3; and Cheyenne, Wyo., 32 pCi/m^3. Cheyenne also reported 341 nCi/m^2 in deposition. Topeka, Kans., reported 93 nCi/m^2 in deposition. These elevated levels of radioactivity are attributed to the atmospheric nuclear test conducted by the Peoples Republic of China on January 7, 1972. All other field estimates reported were within normal limits for the reporting stations.

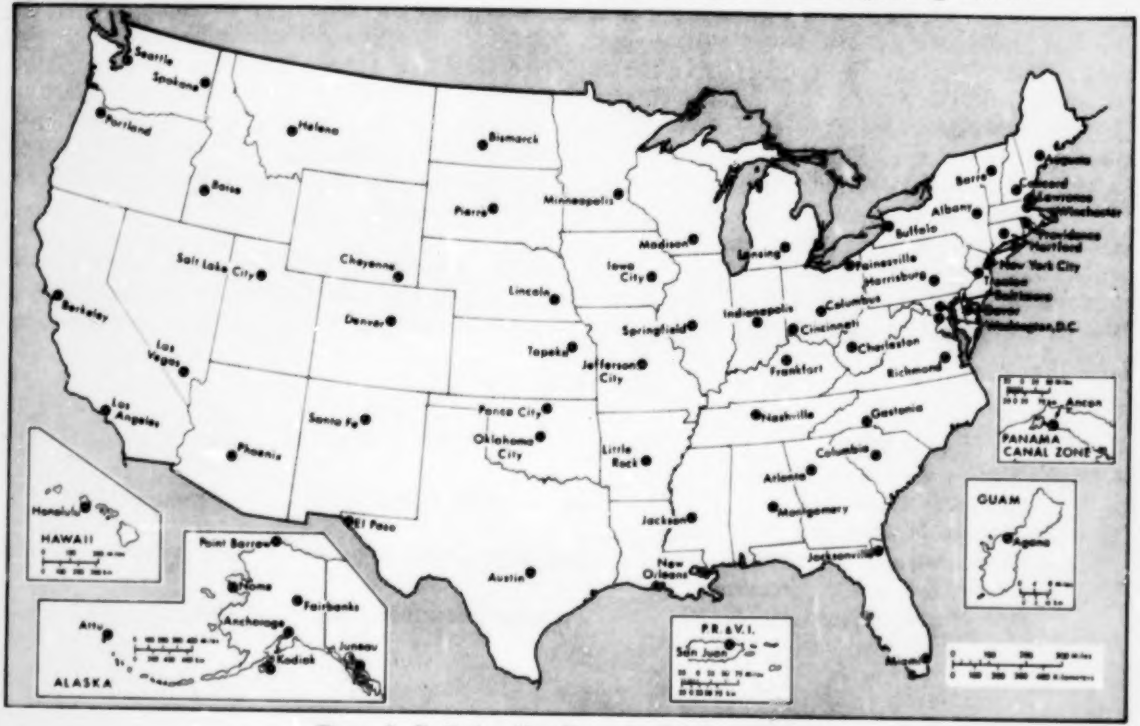
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Madison
Lansing
Iowa City
Lincoln
Denver
Berkeley
Springfield
Indianapolis
Columbus
Cincinnati
Topeka
Jefferson City
Las Vegas
Charleston
Frankfort
Richmond
Los Angeles
Ponca City
Santa Fe
Oklahoma City
Phoenix
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
GUAM
Agana
Ancon
PANAMA CANAL ZONE

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, January 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	3	0	1	8	145	8	145	15
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	30	1	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	13	12	3	7	0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	0				4	36	4	36	0
	Los Angeles	21	8	1	2	0				
C.Z:	Ancon	15	0	0	0	0				
Colo:	Denver	21	28	0	3	1	1	[b]		
Conn:	Hartford	21	1	0	0	9	56	9	56	0
Del:	Dover	18	1	0	0	0				
D.C:	Washington	0				0				
Fla:	Jacksonville	21	2	0	1	6	107	4	78	18
	Miami	17	1	0	0	1	13	1	13	0
Ga:	Atlanta	21	2	1	2	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	21	1	0	0	5	72	[b]		
Idaho:	Boise	21	10	0	1	6	38	6	38	0
Ill:	Springfield	15	3	0	1	0				
Ind:	Indianapolis	20	1	0	0	0				
Iowa:	Iowa City	19	1	0	0	1	9	1	9	0
Kans:	Topeka	19	3	0	1	3	6	3	6	93
Ky:	Frankfort	0				0				
La:	New Orleans	16	1	0	0	9	159	[b]		
Maine:	Augusta	21	1	0	0	8	68	8	68	0
Md:	Baltimore	21	1	0	0	6	49	6	49	0
Mass:	Lawrence	21	2	0	0	5	46	4	43	0
	Winchester	18	2	0	0	8	66	8	66	0
Mich:	Lansing	21	1	0	0	0				
Minn:	Minneapolis	21	3	0	0	1	5	1	5	1
Miss:	Jackson	19	6	0	0	5	154	4	151	0
Mo:	Jefferson City	21	2	0	1	2	7	2	7	1
Mont:	Helena	17	1	0	1	1	5	1	5	0
Nebr:	Lincoln	18	3	0	1	1	2	1	2	0
Nev:	Las Vegas	20	12	0	3	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	8	70	8	70	0
N. Mex:	Santa Fe	15	21	0	2	0				
N.Y:	Albany	18	1	0	0	0				
	Buffalo	21	2	0	0	0				
	New York City	0				0				
N.C:	Gastonia	14	7	1	2	5	85			
N. Dak:	Bismarck	21	1	0	0	5	17	5	17	1
Ohio:	Cincinnati	0				0				
	Columbus	4	1	0	0	0				
	Painesville	21	1	0	0	9	58	8	57	14
Okla:	Oklahoma City	4	5	0	1	0				
	Ponca City	21	5	0	1	1	4	1	4	0
Oreg:	Portland	18	1	0	0	9	161	9	161	15
Pa:	Harrisburg	17	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	18	1	0	0	0				
S.C:	Columbia	16	4	0	1	6	151	6	151	0
S. Dak:	Pierre	21	3	0	1	0				
Tenn:	Nashville	19	9	0	1	9	133	9	133	10
Tex:	Austin	19	27	1	4	4	51	[b]		
	El Paso	11	8	1	4	0				
Utah:	Salt Lake City	30	25	0	2	5	17	5	17	12
Vt:	Barre	21	1	0	0	10	54	10	54	7
Va:	Richmond	19	1	0	0	3	25	3	25	9
Wash:	Seattle	9	1	0	0	8	101	[b]		
	Spokane	20	1	0	0	0				
W. Va:	Charleston	18	4	0	1	12	116	12	116	17
Wisc:	Madison	20	1	0	0	3	10	3	10	2
Wyo:	Cheyenne	21	32	0	2	1	5	1	5	341
Network summary		1,026	32	0	1	188	70	5	53	19

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] January 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for January 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, January 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	17	0.2	0.0	0.1	184	3.2
Coral Harbour	17	.1	.0	.1	87	.4
Edmonton	17	.1	.0	.1	27	.6
Ft. Churchill	17	.1	.0	.1	108	.3
Fredericton	17	.8	.0	.2	18	1.3
Goose Bay	17	.2	.0	.1	17	.9
Halifax	17	.7	.0	.1	267	2.5
Inuvik	13	.1	.0	.1	26	.3
Montreal	16	.5	.0	.2	86	3.4
Moosonee	16	.2	.0	.1	24	1.6
Ottawa	5	.2	.0	.1	48	2.9
Quebec	17	.8	.0	.2	62	.7
Regina	17	.1	.0	.1	22	2.8
Resolute	17	.1	.0	.0	4	.2
St. John's, Nfld	17	.3	.0	.1	7	.9
Saskatoon	17	.1	.0	.1	17	.4
Sault Ste. Marie	NS				24	2.4
Thunder Bay	17	.5	.0	.1	21	1.0
Toronto	17	.5	.0	.1	36	1.6
Vancouver	17	.2	.0	.0	19	1.5
Whitehorse	17	.1	.0	.1	18	.5
Windsor	17	.5	.0	.1	52	1.2
Winnipeg	17	.1	.0	.1	28	4.5
Yellowknife	17	.1	.0	.1	71	.4
Network summary	373	0.8	0.0	0.1	53	1.5

NS, no sample.

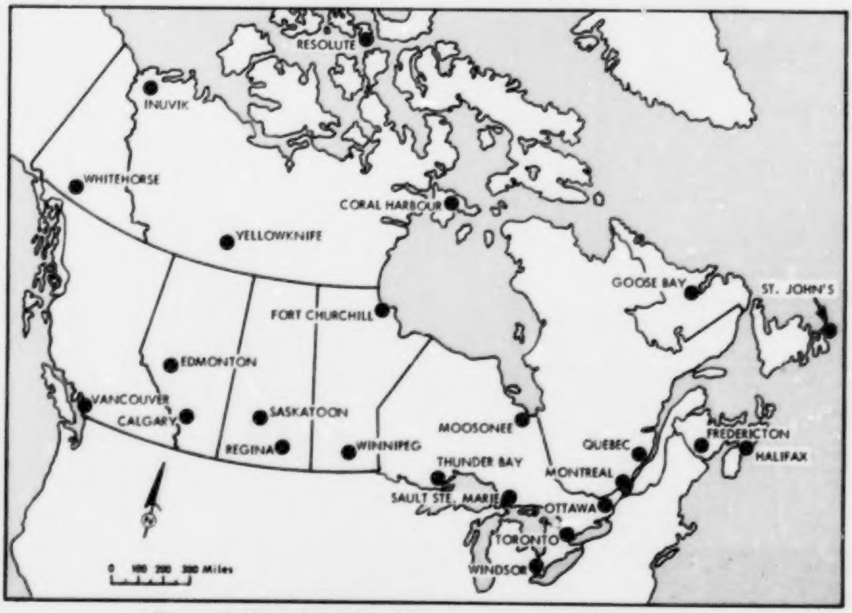
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program
January 1972

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The January 1972 air monitoring results from the participating countries are given in table 3.

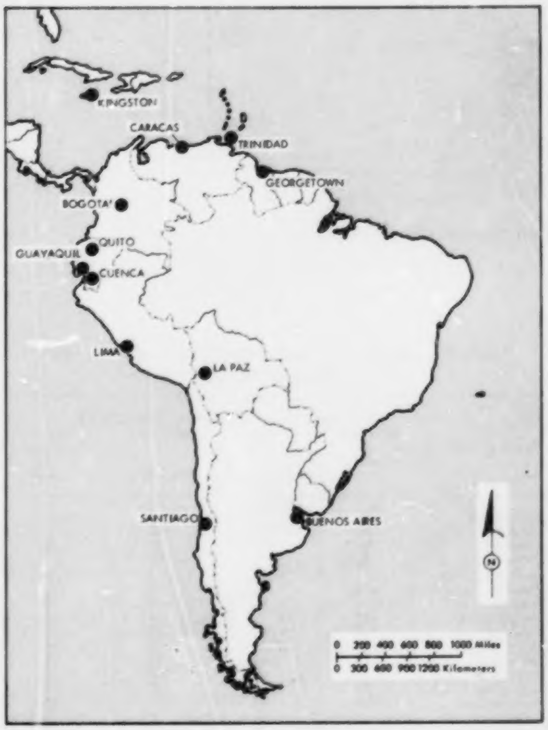

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, January 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	18	0.15	0.00	0.04
Chile:	Santiago	26	.41	.05	.17
Colombia:	Bogota	20	.09	.00	.02
Ecuador:	Cuenca	1	.02	.02	.02
	Guayaquil	8	.17	.06	.11
	Quito	12	.04	.00	.01
Guyana:	Georgetown	10	.01	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	19	.31	.02	.10
Venezuela:	Caracas	18	.06	.00	.03
West Indies:	Trinidad	0			
Pan American summary		132	0.41	0.00	0.07

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

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4. California Air Sampling Program
January 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a contin-

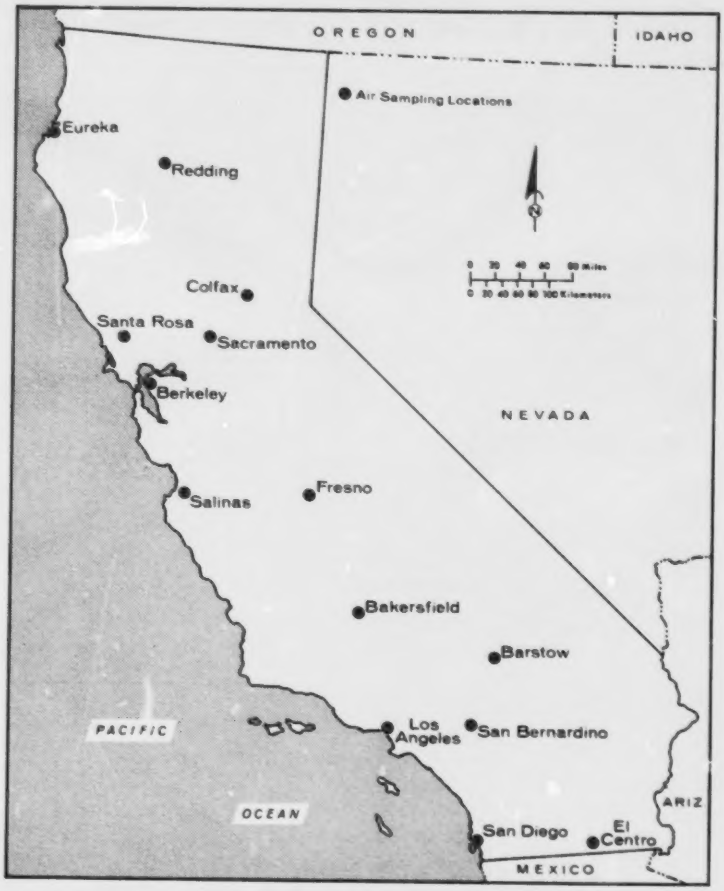
OREGON
IDAHO
Air Sampling Locations
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
San Diego
El Centro
ARIZ
MEXICO

Figure 4. California air sampling program stations

uous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for the month of January 1972.

Table 4. Gross beta radioactivity in California air January 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	31	1.51	0.10	0.39
Barstow	30	3.83	.10	.84
Berkeley	30	2.98	.00	.40
Colfax	31	5.50	.03	.50
El Centro	31	6.70	.04	1.31
Eureka	25	.48	.00	.12
Fresno	31	2.94	.07	.42
Los Angeles	31	8.12	.00	1.13
Redding	29	.90	.04	.23
Sacramento	28	2.11	.07	.33
Salinas	31	4.37	.16	.82
San Bernardino	31	7.66	.11	1.18
San Diego	31	2.35	.07	.73
Santa Rosa	31	.83	.00	.27
Summary	421	8.12	0.00	0.62

5. Mexican Air Monitoring Program February–December 1971

Instituto Nacional de Energia Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comisión Nacional de Energia Nuclear (CNEN). In December 1971, the CNEN became the Instituto Nacional de Energia Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energia Nuclear, the Comite de Seguridad Radiologica (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Seccion de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plants and the Nuclear Center of Mexico.

Since radioactivity in air particulates has decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México, D.F.; Chihuahua; Ensenada; Torreón; Veracruz; and Mérida, (figure 5). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum, and average beta radioactivity in surface air from February 1971 through December 1971 are presented in table 5. Statistically it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

Table 5. Mexican gross beta radioactivity of airborne particulates, February through December 1971

Station	Gross beta radioactivity (pCi/m^3)										
	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Chihuahua:											
Maximum	1.54	1.17	1.58	1.66	0.59	0.38	1.27	0.45	<0.20	0.70	0.42
Minimum	.30	.49	.42	.25	<.20	<.20	<.20	<.20	<.20	<.20	<.20
Average	.63	.70	.71	.89	(a)	.22	.42	<.20	<.20	.28	<.20
Ensenada:											
Maximum	.51	1.89	.69	1.53	1.00	1.47	1.84	<.20	.62	.75	<.20
Minimum	.18	.32	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
Average	.32	.86	.27	.39	.36	.56	.97	<.20	<.20	.49	<.20
Merida:											
Maximum	.97	1.11	.95	.90	.68	.70	1.56	<.20	.65	<.20	<.20
Minimum	.19	.27	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
Average	.40	.57	<.20	(a)	<.20	.22	.92	<.20	<.20	<.20	<.20
Mexico, D.F:											
Maximum	.39	.55	.53	<.20	.60	<.20	NS	NS	<.20	.55	<.20
Minimum	.11	.13	<.20	<.20	<.20	<.20	NS	NS	<.20	<.20	<.20
Average	.25	.31	<.20	<.20	<.20	(a)	NS	NS	<.20	<.20	<.20
Torreon:											
Maximum	1.80	1.83	.68	.55	.56	NS	1.10	<.20	<.20	.63	.63
Minimum	.25	.34	<.20	<.20	<.20	NS	<.20	<.20	<.20	<.20	<.20
Average	.65	.97	<.20	<.20	.23	NS	.47	<.20	<.20	<.20	<.20
Veracruz:											
Maximum	NS	.49	<.20	.56	.56	NS	1.11	<.20	<.20	<.49	<.20
Minimum	NS	.32	<.20	<.20	<.20	NS	<.20	<.20	<.20	<.20	<.20
Average	NS	(a)	<.20	(a)	(a)	NS	.91	<.20	<.20	<.20	<.20

[a] Average not calculated for less than 5 samples.
NS, no sample.

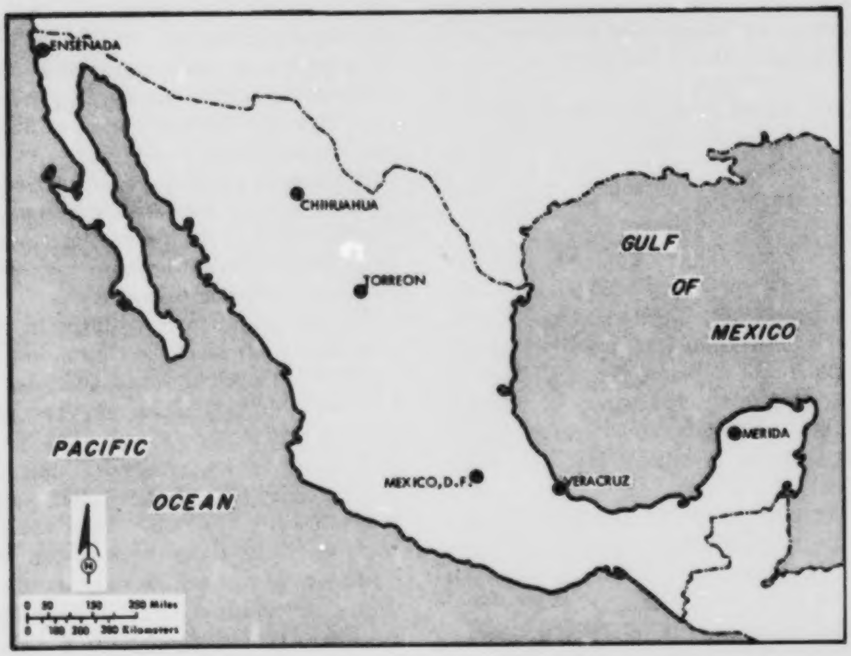

Figure 5. Mexican air sampling locations

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(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

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(6) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August-December 1970 and January 1971. Radiol Health Data Rep 12:525-528 (October 1971).

(7) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comision Nacional de Energia Nuclear, Direccion General de Seguridad Radiologica (1966).

Air Surveillance Network, December 1971 and January 1972

Western Environmental Research Laboratory
Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the Western Environmental Research Laboratory (WERL), Las Vegas, Nev, consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

The stations are operated by State health department personnel and by private individuals

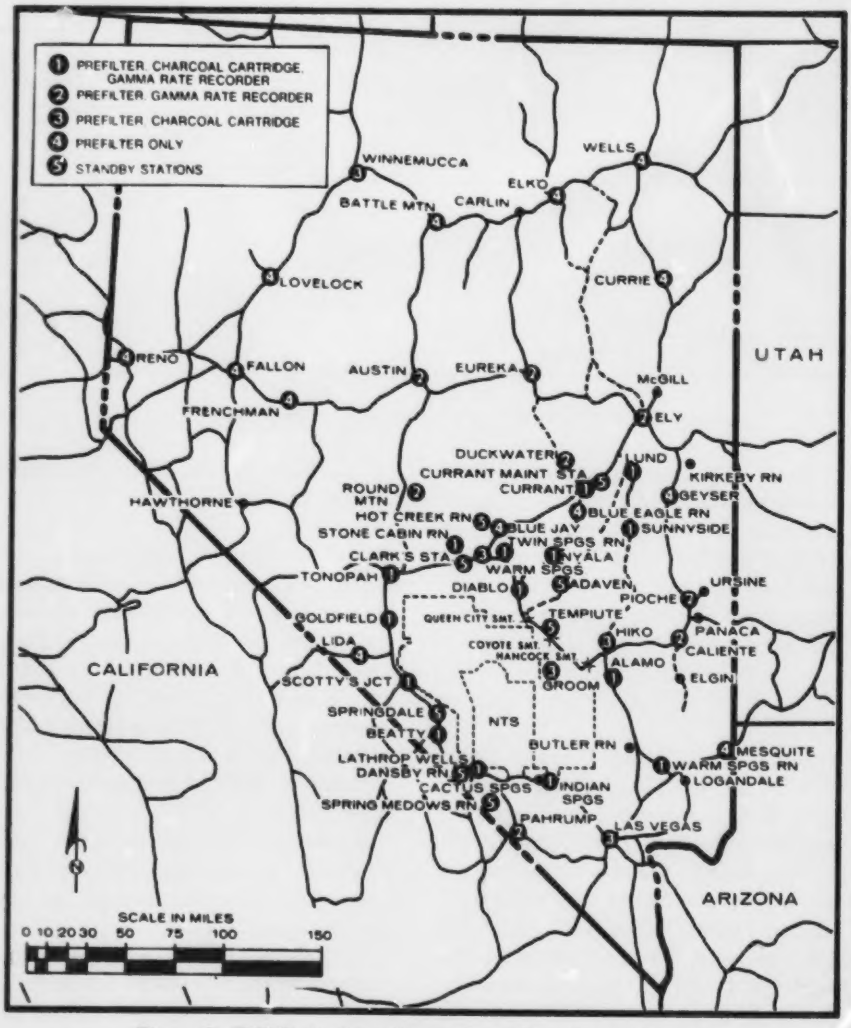
① PREFILTER, CHARCOAL CARTRIDGE, GAMMA RATE RECORDER
② PREFILTER, GAMMA RATE RECORDER
③ PREFILTER, CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
WINNEMUCCA
WELLS
ELKO
CARLIN
BATTLE MTN
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
UTAH
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT STA
KIRKEBY RN
ROUND MTN
CURRANT
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE EAGLE RN
BLUE JAY
SUNNYSIDE
STONE CABIN RN
TWIN SPGS RN
CLARK'S STA
NYALA
TONOPAH
WARM SPGS
URSINE
DIABLO
ADAVEN
PIOCHE
QUEEN CITY SMT.
TEMPIUTE
GOLDFIELD
HIKO
PANACA
COYOTE SMT.
HANCOCK SMT.
CALIENTE
LIDA
ALAMO
CALIFORNIA
GROOM
ELGIN
SCOTTY'S JCT
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEDOWS RN
PAHRUMP
LAS VEGAS
N
ARIZONA
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. WERL Air Surveillance Network stations in Nevada

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[1] The ASN is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

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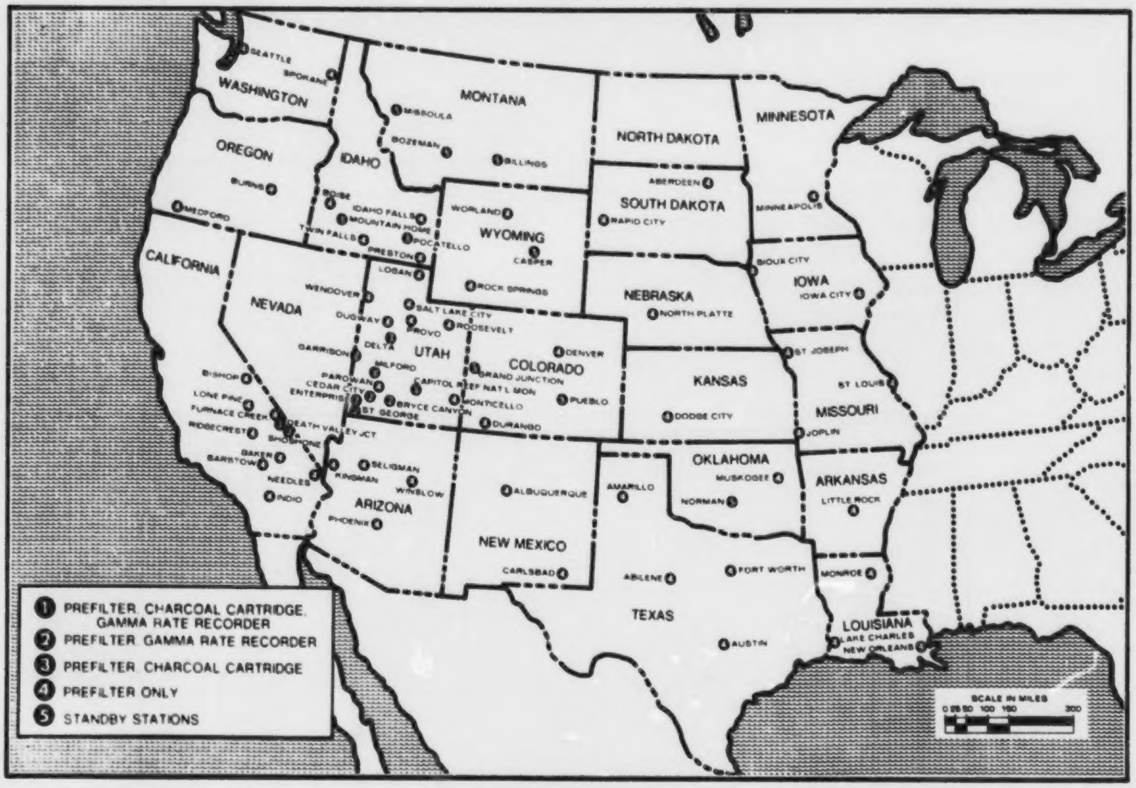
WASHINGTON
SEATTLE
SPOKANE
MONTANA
MISSOULA
BOZEMAN
BILLINGS
NORTH DAKOTA
MINNESOTA
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
WYOMING
WORLAND
CASPER
ROCK SPRINGS
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNEAPOLIS
CALIFORNIA
NEVADA
LOGAN
WENDOVER
DUGWAY
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
GARRISON
UTAH
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST GEORGE
BRYCE CANYON
CAPITOL REEF NAT L MON
MONTICELLO
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
KANSAS
DODGE CITY
MISSOURI
ST JOSEPH
ST LOUIS
JOPLIN
BISHOP
LONE PINE
FURNACE CREEK
DEATH VALLEY JCT
RIDGECREST
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
KINGMAN
SELIGMAN
WINSLOW
ARIZONA
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
OKLAHOMA
MUSKOGEE
NORMAN
AMARILLO
ARKANSAS
LITTLE ROCK
TEXAS
ABILENE
FORT WORTH
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
❶ PREFILTER, CHARCOAL CARTRIDGE, GAMMA RATE RECORDER
❷ PREFILTER, GAMMA RATE RECORDER
❸ PREFILTER, CHARCOAL CARTRIDGE
❹ PREFILTER ONLY
❺ STANDBY STATIONS
SCALE IN MILES
0 25 50 100 150 300

Figure 2. WERL Air Surveillance Network stations outside Nevada

on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates during December 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m^3. For averaging purposes individual concentrations which are below the minimum detectable concentration (0.06-0.07 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3.

No radionuclides were identified by gamma spectrometry on any filters collected during December. No radioactivity was identified on any of the charcoal cartridges.

Table 2 presents the monthly average gross beta concentrations in air for each of the network stations for January 1972. The highest gross beta concentration within the network was 91 pCi/m^3 at Rock Springs, Wyo. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m^3. Averages are calculated in the same manner as described for table 1.

From gamma spectrometry results, fission products in varying combinations of barium-140, tellurium-132, iodine-131, ruthenium-103, and zirconium-95 were identified on samples collected in Arizona, California, Colorado, Idaho, Iowa, Kansas, Louisiana, Minnesota, Missouri, Montana, Nebraska, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Wash-

Table 1. Summary of gross beta radioactivity concentrations in air December 1971

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Ariz:	Kingman	31	0.2	<0.1	0.1
	Phoenix	30	.2	<.1	.1
	Seligman	30	.3	<.1	.1
	Winslow	31	.3	<.1	.1
Ark:	Little Rock	10	.7	<.1	.2
Calif:	Baker	27	.3	.1	.1
	Barstow	31	.3	<.1	.1
	Bishop	30	.4	<.1	.1
	Death Valley Junction	30	.3	<.1	.1
	Furnace Creek	32	<.4	<.1	.1
	Indio	31	.3	<.1	.1
	Lone Pine	26	.3	.1	.1
	Needles	28	.4	.1	.1
	Ridgecrest	31	.4	<.1	.1
	Shoshone	27	.3	<.1	.1
Colo:	Denver	23	.2	.1	.1
	Durango	31	.2	.1	.1
Idaho:	Boise	31	.5	<.1	.1
	Idaho Falls	22	.1	<.1	.1
	Preston	31	.2	<.1	.1
	Twin Falls	31	.3	<.1	.1
Iowa:	Iowa City	18	.2	.1	.1
	Sioux City	27	.2	<.1	.1
Kans:	Dodge City	31	.2	<.1	.1
La:	Lake Charles	22	.2	<.1	.1
	Monroe	18	.2	<.1	.1
	New Orleans	19	.2	<.1	.1
Minn:	Minneapolis	20	.2	.1	.1
Mo:	Joplin	31	.2	<.1	.1
	St. Joseph	30	.3	<.1	.1
	St. Louis	31	.2	<.1	.1
Nebr:	North Platte	27	.5	.1	.1
Nev:	Alamo	31	.2	<.1	.1
	Austin	23	.3	<.1	.1
	Battle Mountain	30	.4	<.1	.1
	Beatty	32	<.2	<.1	.1
	Blue Eagle Ranch (Currant)	31	<.3	<.1	.1
	Blue Jay	31	.2	<.1	.1
	Caliente	32	<.8	<.1	.1
	Currant Ranch	32	.3	<.1	.1
	Currie	31	.3	<.1	.1
	Diablo	31	.3	<.1	.1
	Duckwater	26	.5	<.1	.1
	Elko	31	.3	<.1	.1
	Ely	30	.2	<.1	.1
	Eureka	31	.2	<.1	.1
	Fallini's Twin Springs Ranch	31	.3	<.1	.1
	Fallon	31	.2	<.1	.1
	Frenchman Station	28	.3	<.1	.1
	Geyser Maintenance Station	31	.2	<.1	.1
	Goldfield	29	.2	<.1	.1
	Groom Lake	26	.2	<.1	.1
	Hiko	31	.3	<.1	.1
	Indian Springs	31	.2	<.1	.1
	Las Vegas	18	.2	<.1	.1
	Lathrop Wells	29	.3	<.1	.1
	Lida	31	.3	<.1	.1
	Lovelock	31	.3	<.1	.1
	Lund	31	.4	<.1	.1
	Mesquite	31	.3	<.1	.1
	Nyala	31	.3	<.1	.1
	Pahrump	9	.1	<.1	.1
	Pioche	31	.2	<.1	.1
	Reno	31	.4	<.1	.1
	Round Mountain	32	<1.2	<.1	.1
	Scotty's Junction	30	.2	<.1	.1
	Stone Cabin Ranch	31	.3	<.1	.1
	Sunnyside	26	.2	<.1	.1
	Tonopah	31	.3	<.1	.1
	Tonopah Test Range	29	.2	<.1	.1
	Warm Springs Ranch	31	.2	<.1	.1
	Wells	31	.2	<.1	.1
	Winnemucca	15	.3	<.1	.1
N. Mex:	Albuquerque	22	.2	.1	.1
	Carlsbad	29	.3	<.1	.2
Okla:	Muskogee	31	.3	<.1	.1
Oreg:	Burns	30	.3	<.1	.1
	Medford	30	.2	<.1	.1
S. Dak:	Aberdeen	31	.2	.1	.1
	Rapid City	31	.4	<.1	.1
Tex:	Abilene	28	.4	.1	.1
	Amarillo	31	.2	<.1	.1
	Austin	14	.2	<.1	.1
	Fort Worth	31	.3	<.1	.1

See footnotes at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air December 1971—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Utah:	Bryce Canyon	16	.2	<.1	.1
	Cedar City	31	.2	<.1	.1
	Delta	31	.2	<.1	.1
	Dugway	31	.2	<.1	.1
	Enterprise	31	.4	.1	.1
	Garrison	32	<.3	<.1	.1
	Logan	31	.2	<.1	.1
	Milford	31	.3	<.1	.1
	Monticello	11	.2	<.1	.1
	Parowan	31	.2	<.1	.1
	Provo	31	.2	<.1	.1
	Roosevelt	31	.3	<.1	.1
	Salt Lake City	31	.3	<.1	.1
	St. George	31	.2	<.1	.1
	Wendover	31	.3	<.1	.1
Wash:	Seattle	21	.5	<.1	.1
	Spokane	21	.4	<.1	.1
Wyo:	Rock Springs	31	.2	<.1	.1
	Worland	30	.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.

Table 2. Summary of gross beta radioactivity concentrations in air January 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Ariz:	Kingman	31	12.0	<.1	1.2
	Phoenix	28	9.4	<.1	1.7
	Seligman	31	34.0	<.1	2.1
	Winslow	30	30.0	.1	2.1
Ark:	Little Rock	9	.3	<.1	.2
Calif:	Baker	29	5.1	.1	.8
	Barstow	31	6.8	<.1	1.0
	Bishop	31	43.0	<.1	2.1
	Death Valley Junction	31	22.0	<.1	1.3
	Furnace Creek	31	5.4	<.1	.8
	Indio	31	11.0	.1	1.5
	Lone Pine	23	28.0	<.1	2.0
	Needles	27	4.0	<.1	1.1
	Ridgecrest	31	8.3	<.1	.8
	Shoshone	29	32.0	<.1	1.7
Colo:	Denver	21	42.0	<.1	3.0
	Durango	29	35.0	<.1	2.5
Idaho:	Boise	31	17.0	<.1	.9
	Idaho Falls	20	5.7	.1	.4
	Preston	29	90.0	<.1	3.6
	Twin Falls	30	26.0	<.1	1.3
Iowa:	Iowa City	20	2.2	<.1	.3
	Sioux City	28	1.4	<.1	.2
Kans:	Dodge City	29	3.1	.1	.5
La:	Lake Charles	21	7.5	<.1	.9
	Monroe	18	26.0	<.1	1.1
	New Orleans	17	4.5	<.1	.6
Minn:	Minneapolis	21	2.4	.1	.2
Mo:	Joplin	31	5.7	<.1	.5
	St Joseph	31	2.3	<.1	.4
	St. Louis	31	1.5	<.1	.2
Nebr:	North Platte	25	2.9	.1	.5
Nev:	Alamo	31	16.0	<.1	1.1
	Austin	23	13.0	<.1	.7
	Battle Mountain	31	11.0	<.1	.7
	Beatty	31	13.0	<.1	1.3
	Blue Eagle Ranch (Currant)	30	8.7	<.1	.7
	Blue Jay	31	19.0	<.1	1.0
	Caliente	31	30.0	<.1	1.7
	Currant Ranch	30	24.0	<.1	1.3

See footnotes at end of table.

Table 2. Summary of gross beta radioactivity concentrations in air January 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Nev:	Currie	31	22.0	<.1	1.4
	Diablo	31	16.0	<.1	1.0
	Duckwater	29	14.0	<.1	1.0
	Elko	31	8.3	<.1	.9
	Ely	31	9.1	<.1	.8
	Eureka	31	17.0	<.1	1.1
	Fallini's Twin Springs Ranch	31	16.0	<.1	.9
	Fallon	31	7.1	<.1	.5
	Frenchman Station	31	9.2	<.1	.6
	Geyser Maintenance Station	28	7.8	<.1	.8
	Goldfield	30	15.0	<.1	.9
	Groom Lake	31	21.0	<.1	1.5
	Hiko	30	18.0	<.1	1.3
	Indian Springs	31	25.0	<.1	1.8
	Las Vegas	21	13.0	<.1	1.4
	Lathrop Wells	29	27.0	<.1	1.5
	Lida	31	14.0	<.1	1.1
	Lovelock	32	7.7	<.1	.7
	Lund	30	19.0	<.1	1.3
	Mesquite	31	7.8	<.1	1.1
	Nyala	31	22.0	<.1	1.2
	Pahrump	21	34.0	<.1	1.9
	Pioche	31	23.0	<.1	1.4
	Reno	30	6.2	<.1	.7
	Round Mountain	31	41.0	<.1	2.4
	Scotty's Junction	30	13.0	<.1	1.1
	Stone Cabin Ranch	31	31.0	<.1	1.4
	Sunnyside	30	10.0	<.1	.8
	Tonopah	31	13.0	<.1	1.0
	Tonopah Test Range	27	8.4	<.1	.9
	Warm Springs Ranch	31	5.1	<.1	.8
	Wells	31	5.3	<.1	.6
	Winnemucca	31	6.6	<.1	.7
N. Mex:	Albuquerque	25	47.0	<.1	2.6
	Carlsbad	31	13.0	<.1	1.5
Okla:	Muskogee	31	10.0	.1	.6
Oreg:	Burns	30	3.0	<.1	.5
	Medford	26	.9	<.1	.1
S. Dak:	Aberdeen	24	.4	<.1	.1
	Rapid City	30	.5	<.1	.1
Tex:	Abilene	29	8.6	<.1	1.1
	Amarillo	31	37.0	<.1	1.9
	Austin	17	23.0	<.1	2.1
	Fort Worth	31	33.0	<.1	1.5
Utah:	Bryce Canyon	18	23.0	<.1	2.0
	Cedar City	31	8.7	<.1	1.1
	Delta	29	16.0	<.1	1.3
	Dugway	31	17.0	<.1	.9
	Enterprise	31	13.0	<.1	1.2
	Garrison	31	14.0	<.1	1.4
	Logan	31	64.0	<.1	2.7
	Milford	30	11.0	.1	1.1
	Monticello	25	23.0	<.1	2.0
	Parowan	31	13.0	<.1	1.0
	Provo	31	49.0	.1	2.8
	Roosevelt	31	55.0	<.1	2.5
	Salt Lake City	31	68.0	<.1	3.2
	St. George	31	17.0	<.1	1.5
	Wendover	31	15.0	<.1	1.4
Wash:	Seattle	20	1.8	<.1	.2
	Spokane	20	.5	<.1	.1
Wyo:	Rock Springs	30	91.0	<.1	3.9
	Worland	15	3.9	<.1	.4

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.

ington, and Wyoming. The highest concentrations of these radionuclides, respectively, were 6.0 pCi/m³ (Pueblo), 9.6 pCi/m³ (Salt Lake City), 8.1 pCi/m³ (Pueblo), 2.3 pCi/m³ (Pueblo), and 1.7 pCi/m³ (Pueblo). These radionuclides are attributed to a non-U.S. nuclear test conducted on January 7, 1972.

Complete summaries of the daily station results are distributed to EPA regional offices and State agencies. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site January-June 1967[1]

Western Environmental Research Laboratory,[2]
EPA, and Nevada Operations Office, AEC

During January through June 1967, 16 announced underground nuclear tests were conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS) as a part of Operation Latchkey. In addition, four Experimental Plans of the Phoebus 1B reactor test series were conducted at the Nuclear Rocket Development Station (NRDS). The Public Health Service (PHS) carried out a program of radiological surveillance of the areas offsite for the Operational Safety Division of the AEC Nevada Operations Office (AEC/NVOO) under a Memorandum of Understanding between the AEC and the PHS.

The Southwestern Radiological Health Laboratory (SWRHL) conducted the program of radiological monitoring and environmental sampling in the offsite areas surrounding the restricted area enclosed within the NTS and the Nellis Air Force Range. This overall complex of the NTS and the Nellis Air Force Range includes the NRDS and the Tonopah Test Range (TTR) and for simplicity will be called the test range complex throughout this report. Although routine sampling and monitoring was done within a 300-mile radius around the test range complex, surveillance was extended as necessary to provide additional coverage.

Operational procedures

Ground monitoring Before each event, mobile monitoring teams are deployed in the offsite area to locations most likely to be affected by a release of radioactive material. If a release occurs, the teams conduct a ground monitoring program directed by two-way radio and telephone communications from Control Point headquarters. Ground monitoring continues until radioactivity becomes too low to necessitate further monitoring.

Each monitor is equipped with an Eberline E-500B Radiation Monitor, a Baird-Atomic Model 904148 Scintillator, and a Victoreen Radector, Model No. AGB-50B-Sr. The Eberline E-500B has a range of 0 to 200 mR/h gamma or beta-gamma detection in four scales with an external halogen quenched GM tube and a 0 to 2,000 mR/h range, gamma only, from an internal Anton 302 tube. The Radector has a range of 0.05 to 50,000 mR/h on two scales. This instrument employs an inert gas ionization chamber. The Baird-Atomic Model 904148 scintillator has a range of 0 to 3 mR/h in three scales and has an internally mounted NaI (Tl) crystal. This instrument is used primarily for low level gamma detection. Errors associated with these instruments are of the order of ±20 percent when calibrated with a cesium-137 source.

Exposure rate recorders To supplement the ground monitoring program, Eberline RM-11 Exposure Rate Recorders are utilized at fixed locations to document cloud passage, thereby allowing mobile monitoring teams to continue following any release of radioactivity as it moves through offsite areas. These recorders have a Geiger tube detector and operate on 110V ac. They have a 0.01 to 100 mR/h range and are accurate to ±20 percent. Gamma exposure rate is recorded on a 30-hour strip chart.

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[1] This article is a summary of report No. SWRHL-47r, "Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from January June 1967."

[2] Formerly the Southwestern Radiological Health Laboratory of the U.S Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health.

Aerial cloud tracking and sampling A PHS aerial monitoring team was available for each experiment. In the event of a release of radioactivity, this team, equipped with instruments identical to those used by ground monitors, tracked the effluent. Normally an Air Force U3-A aircraft is used in this tracking mission.

Aerial cloud tracking by this team is used primarily to measure relative radiation intensities and to indicate cloud position, speed and direction. This information is used to position ground monitors. PHS Turbo-Beech aircraft are specially equipped to perform cloud measurements and collect a variety of samples. The data and samples are used to determine average cloud concentrations and cloud inventories of gross radioactivity and specific radionuclides. Samples are collected for analysis of particulates, reactive gas, inert gas, water, and CO_2. Samples are also collected to determine size-activity relations of the particulate activity.

Air sampling During this 6-month period, the SWRHL Air Surveillance Network (ASN) was comprised of 105 stations operating in every State west of the Mississippi except Montana and North Dakota. The air sampler used in the ASN was a Gelman "Tempest."

The "Tempest" consists of a Gast Model 1550 vacuum pump driven by a General Electric ½ horsepower motor. The pump runs at 1,440 rpm with an average flow rate of approximately 10 cfm. The sampler is equipped to use a 4-inch diameter Whatman 541 filter paper and an MSA type BM2306 charcoal cartridge. The total volume of air sampled is calculated from the total sampling time and an average of vacuum readings taken at the beginning and the end of the sampling period.

Milk and water sampling The previously established milk sampling program was continued throughout the 6-month period. About 20 sources, consisting of commercial dairies and private producers were routinely sampled during this period, generally on a monthly basis. A total of 144 samples was collected from these locations. In the event of a release of radioactive material, sampling was intensified.

Water samples were collected on a routine basis, unless circumstances dictated special source sampling. Both potable and nonpotable water supplies were sampled. During this period, 374 water samples were collected from 74 sources. Many of these sources were sampled on a monthly basis.

Vegetation sampling Normally, vegetation samples were collected only in the event of a release of radioactive material. The analytical results of these samples were used to delineate the fallout pattern.

Film badges Approximately 164 residents in the offsite area were issued film badges during this period. These film badges were changed each month and were processed by the Radiological Sciences Department, Reynolds Electrical and Engineering Company, Inc. Approximately 90 film badge stations were used to provide more complete coverage. Each station held five film badges and 70 stations were each equipped with three EG&G Model TL-12 thermoluminescent dosimeters (TLD).

The film badge used is made of DuPont type 555 film. Exposure, as determined from this film, is accurate to ±50 percent in the 30 to 100 mR range and ±10 percent in the 100 to 2,000 mR range. The TLD's have a low energy response cutoff at 50 keV and are not energy-dependent in the range from 50 keV to several MeV. According to past TLD data, a reading of 10 mR above the previous month's background constitutes a detectable exposure.

Community relations Frequent contacts with the offsite population, schools and civic groups provided the opportunity to explain the role of the PHS with respect to the programs of the AEC. As a result of favorable community relations, a number of offsite residents took part in the environmental sampling program; all routine air sampling stations except Las Vegas were operated by local citizens, and many persons volunteered to wear film badges.

Medical and veterinarian services A PHS medical officer was available in the event any cases of a medical nature arose as a result of the test series. No such cases were reported from any source. Veterinarian services were also provided. PHS veterinarians maintained liaison with livestock producers in the area, and the program of wildlife and cattle investigation was continued.

Analytical procedures

All environmental samples collected by the PHS were returned to the SWRHL in Las Vegas for radiological analyses. Air sampler prefilters were counted for gross beta activity in a Beckman "Wide Beta" low background (6 ±1 cpm beta) proportional system which has an efficiency of approximately 45 percent for 0.54 MeV betas. After an initial count, if no significant activity was detected, the prefilters were counted at 5 and 12 days after collection. In all other cases, prefilters were recounted a minimum of three times in the first 48 hours following collection. The computational procedure employed depends upon the assumption that a decay constant can be determined for each individual sample and that this constant can then be used to extrapolate the activity to the end of the collection period.

Selected prefilters and all charcoal cartridges were analyzed for gamma-emitting radionuclides by placing them directly on a 4- by 4-inch NaI(T1) crystal coupled to a TMC Model 404C gamma pulse height analyzer viewing energies from 0 to 2 MeV.

The detection capability of the system as shown in table 1 is an empirical estimate obtained from previous data collected under the following conditions.

1. Count time in days after fissioning as indicated by footnotes.
2. Prefilters collect unfractionated fission products resulting in a complex spectrum.
3. MSA charcoal collects gaseous fission products only (primarily iodines).
4. Analysis is performed using an eight nuclide matrix. If other nuclides are present in the sample, their relative proportion is small compared to those eight.
5. Natural activity on air samples is approximately five times system background.

Although the minimum detectable levels for water samples involve the limitations listed in (4) above, the situation is usually simplified by having no background other than that of the system. For a sample containing all of the isotopes of iodine, the error term on threshold values at the 95 percent confidence level is approximately ±50 percent.

Biological discrimination will limit the number of nuclides present in a milk sample to relatively few. Under normal sampling procedures, the short physical half-life will tend to eliminate iodine-132 and iodine-135 from the sample by the time it is counted. At the 95 percent confidence level, reported values for a 40-minute count for milk are ±10 pCi/liter or 10 percent at the time of count, whichever is greater.

After any release of activity from the NTS, milk samples are collected from dairies (processing plants), producing dairy farms, and farms producing milk for their own consumption. Each sample is counted for 40 minutes. No attempt is made to recount samples having low positive values. The lower limit of detection for gamma emitters in milk samples is 20

Table 1. Threshold detectability at time of count of several radionuclides in various samples (95-percent confidence level)

Sample type	Length of count	Radioactivity concentration (pCi)				
		Iodine-131	Tellurium-iodine-132	Iodine-133	Iodine-135	Barium-lanthanum-140
Whatman No. 541 filter	[a]10 minutes	500	1,000	500	1,000	500
	[b]10 minutes	200		200		200
MSA charcoal cartridge	[a]10 minutes	200	400	200	400	200
	[b]10 minutes	100		100		100

[a] Counted at less than 3 days after formation.
[b] Counted at 3 days or more after formation.

pCi/liter at the time of count, and all results below that value are reported as <20 pCi/liter.

All liquid samples are counted in a 3.5-liter inverted well aluminum beakers which are placed on top of a 4- by 4-inch NaI(Tl) crystal coupled to a 400-channel gamma pulse height analyzer. Overall detection efficiency for the 0.364-MeV photopeak of iodine-131 is 6.4 percent. A matrix technique is employed to compute the interference due to the presence of other radionuclides. The input to this matrix is variable, allowing for the simultaneous determination of any eight radionuclides for which detection efficiencies and interference factors have been obtained. Actual computation is performed by an IBM 1620 computer.

After gamma analysis of milk samples was completed, certain samples were analyzed for strontium-89 and strontium-90. After addition of strontium carrier, milk proteins are removed by ion exchange. Following several purification steps, the purified strontium is stored for at least one week to alow for ingrowth of yttrium-90. Strontium and yttrium are separated by nitric acid precipitation and both fractions are counted in a low-background beta counter. The strontium-89 activity is the calculated difference between the total strontium activity and the strontium-90 (as yttrium-90 activity).

Water samples are analyzed for gross beta activity by slowly evaporating an aliquot to dryness in a 2-inch diameter stainless-steel planchet and counting the beta activity in a low background counter.

Results

Underground tests Two of the 16 announced underground nuclear tests resulted in releases of radioactive material which were detected in offsite populated areas. These were the Nash Event, conducted on January 19 and the Umber Event conducted on June 29.

Nash Event

Ground surveillance

The Nash Event was conducted at the NTS on January 19 at 0845 hours Pst. Leaking occurred 11 hours after detonation and continued until 1200 hours Pst on January 20. Winds on shot day and for at least 48 hours following detonation were light and variable near the surface, with a strong inversion at approximately 1,000 feet altitude; hence, vertical mixing was slow. Because of these conditions, the effluent moved both southwest and northeast but, by the time the cloud had traveled to the offsite areas, very little radiation could be detected.

No radiation intensities above background were measured north or east of the NTS by any of the 17 ground monitors stationed at strategic points around the test range complex. However, from 0535 hours to 0930 hours on January 20, external gamma values above background were measured on U.S. Highway 95 from 20 miles west of the Mercury turnoff to 14 miles northwest of Lathrop Wells. The highest exposure rate measured was 0.14 mR/h above background. This measurement was made on Highway 95, 21 miles west of the Mercury turnoff at 0556 hours and again at 0604 hours Pst on January 20. Only one exposure rate recorder indicated activity above background. At Diablo Maintenance Station, 0.01 mR/h, above background was recorded over a 6-hour period beginning at 0930 hours on January 20. No film badges or TLD's collected since the test have indicated exposures resulting from the Nash Event.

Although radioiodines were found in offsite air sampler filter media, as shown in table 2, a negligible amount was contributed by the Nash Event. Comparison of radioiodine levels measured before and after the Nash Event showed that these levels resulted from a Chinese atmospheric nuclear test conducted on December 27, 1966. It can be seen from table 2 that some of the highest gross beta results came from filters collected before the venting. Since these results were from the Chinese test, these filters were not gamma scanned. This Chinese test can probably also be cited as the source of the low amounts of radionuclides detected in the four milk samples collected following the Nash event, as shown in table 3, and for the radioiodines found in the 21 vegetation samples, as shown in table 4.

Aerial surveillance

A PHS Turbo-Beech performed aerial sur-

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Table 2. Air sampling results, Nash Event

Location	Date and time on	Date and time off	Volume (m³)	Collector[a]	Gross beta radio-activity (pCi/m³)	Iodine-131 (pCi/m³)
Beatty	1/18 0802	1/19 0802	497	P	1.3	NA
	1/19 0803	1/20 0807	497	P C	1.2	0.3 .3
	1/20 0808	1/21 0805	497	P C	.7	ND ND
Clarks Station	1/19 0740	1/20 0740	485	P C	.9	ND 1.2
	1/20 0740	1/21 0740	472	P C	.8	ND ND
Diablo	1/18 0650	1/19 0700	513	P C	2.0	NA .8
	1/19 0700	1/20 0700	507	P C	.9	ND .3
	1/20 0700	1/21 0730	517 517	P C	.7	ND .9
Fallini's Ranch	1/19 0830	1/20 0900	486	P C	.4	ND 1.0
	1/20 0900	1/21 1000	516	P C	.3	ND ND
Goldfield	1/19 0800	1/20 0800	509	P C	1.2	.2 ND
	1/20 1535	1/21 1200	435	P C	.8	NA ND
Hiko	1/18 0810	1/19 0810	497	P C	.9	NA .3
	1/19 0810	1/20 0800	495	P C	.8	ND ND
	1/20 0800	1/21 0730	487	P C	.7	ND ND
Indian Springs	1/19 0900	1/20 0900	423	P C	1.2	ND .8
	1/20 0900	1/21 0900	448	P C	.8	ND 1.0
Nyala	1/18 0800	1/19 0800	484	P C	2.6	NA .3
	1/19 0800	1/20 0800	509	P C	.9	.3 .4
	1/20 0800	1/21 0800	509	P C	.7	ND ND
Tonopah	1/18 1400	1/19 1400	497	P	.9	NA
	1/19 1400	1/20 1830	573	P C	.9	ND .2
	1/20 1830	1/21 1800	487	P C	.4	NA ND
Warm Springs	1/18 0900	1/19 0900	485	P	1.3	NA
	1/19 0900	1/20 0900	485	P C	1.1	ND 0.5
	1/20 0900	1/21 0900	485	P C	.6	ND ND
Warm Springs Ranch	1/18 0800	1/19 0730	509	P	1.9	NA
	1/19 0730	1/20 0730	497	P C	1.1	ND .8
	1/20 0900	1/21 1000	516	P C	1.0	NA NA

[a] P, Whatman 541 prefilter C, MSA charcoal cartridge.
NA, no analysis.
ND, nondetectable.

veillance in the offsite area from 1150 to 1245 hours on January 20. Cloud activity was detected at 1157 hours 3 miles east of Lathrop Wells, at 5,000 feet mean sea level (msl) and sampling was commenced at that time. The cloud continued west to the Big Dune. On the return leg towards Lathrop Wells, altitude was changed several times to find the cloud top, which was determined to be 5,100 feet msl. Cloud tracking and sampling was continued at 4,500 feet msl along the path shown in figure 1. Continuous activity was found from Lathrop Wells to the dry lake and to Desert Rock at the Mercury turnoff on Highway 95; then from 5 miles south of the Mercury turnoff to the west side of the dry lake and again near the California border at 1233 hours. On the northbound leg at 1241 hours the southern edge was

Table 3. Milk results, Nash Event

Location in Nevada	Date milked	Concentration (pCi/liter)		
		Iodine-131	Strontium-90	Strontium-89
Lathrop Wells (Martinson Ranch)	1/19/67 PM	20	1.5	0
	1/20/67 PM	ND	NA	NA
Nyala	1/21/67 AM	ND	6.1	8.0
Springdale	1/21/67 AM	ND	1.6	1.0

NA, no analysis.
ND, not detectable.

Table 4. Vegetation samples which showed the presence of fresh fission products, Nash Event

Collection date	Location
January 20, 1967	25.5 miles southeast of Lathrop Wells, Nev.
	25.5 miles southeast of Lathrop Wells, Nev.
	9 miles southeast of Lathrop Wells, Nev.
	9 miles southeast of Lathrop Wells, Nev.
	3 miles southeast of Lathrop Wells, Nev.
	3 miles southeast of Lathrop Wells, Nev.
	Martinson Ranch, Lathrop Wells, Nev.
	Beatty, Nev.
	Beatty, Nev.
	5 miles south of Beatty, Nev.
	5 miles south of Beatty, Nev.
	15 miles south of Beatty, Nev.
	15 miles south of Beatty, Nev.
	20 miles south of Beatty, Nev.
	20 miles south of Beatty, Nev.
January 21, 1967	Coyote Summit, Nev.
	Hancock Summit, Nev.
	Queen City Summit, Nev.
January 20, 1967	Death Valley Junction, Calif.
	Furnace Creek, Calif.
	Shoshone, Calif.

located 5 miles south of Johnnie, Nev. From these measurements an approximate outline of that portion of the cloud south of Highway 95 was determined as shown in figure 1. Using a cloud thickness of 2,000 feet, a volume of 6.8×10^{11} cubic meters was determined for this portion of the cloud.

Particulate activity collected on the filter of the mass air sampler was too low to quantitate by nuclide. The activated charcoal bed behind the filter contained iodine-131. The results are shown in table 5. Aerial samples collected in the vicinity of ground zero showed that the release consisted primarily of inert gases (krypton-85m, krypton-88, and xenon-135). No inert gas samples were collected off the test site.

Table 5. Aerial sampling results, Nash Event

Radioactivity	Average concentration (pCi/m³)	Total radioactivity in cloud (Ci) off NTS at 1200 hours
Iodine-131 (on charcoal)	3.5	2.6
Gross beta particulate	16	11

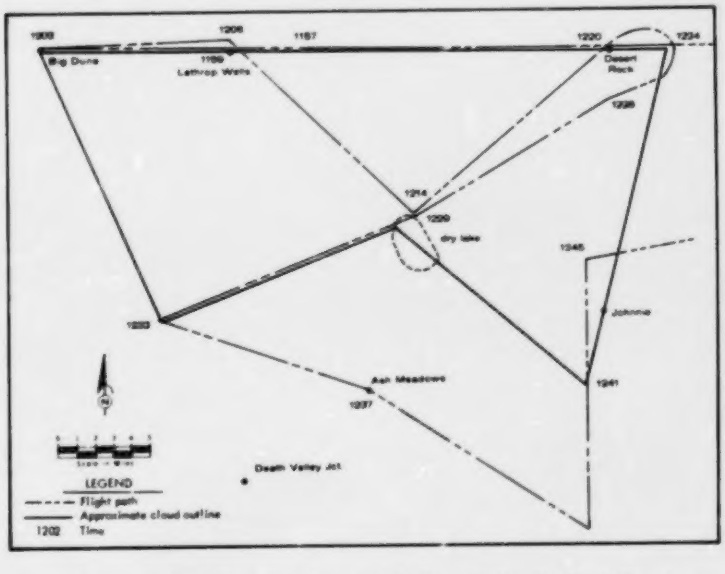

Figure 1. Cloud outline time and flight path for the Nash Event

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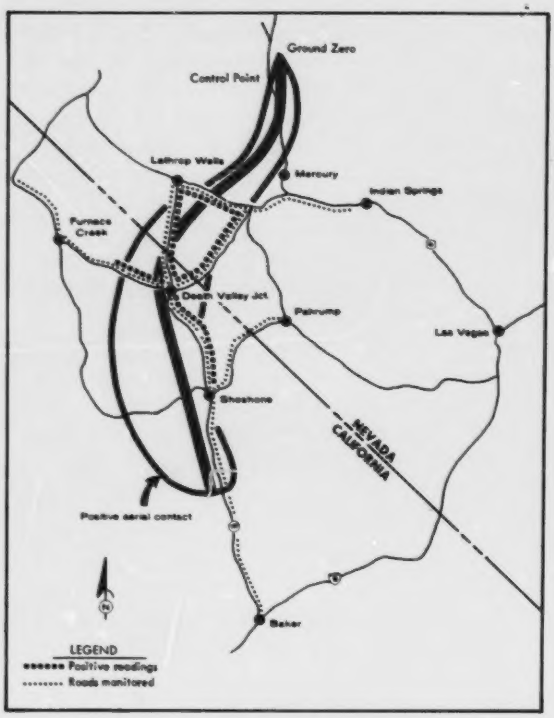
Ground Zero
Control Point
Lathrop Wells
Mercury
Indian Springs
Furnace Creek
Death Valley Jct
Pahrump
Las Vegas
Shoshone
NEVADA
CALIFORNIA
Positive aerial contact
N
Baker
LEGEND
●●●●●● Positive readings
········ Roads monitored

Figure 2. Positive aerial contact and ground monitoring for the Umber Event

Umber Event

Ground surveillance

The Umber Event was an underground nuclear experiment conducted at 0425 hours Pdt on June 29, 1967, at the NTS. Primarily gaseous radioactive material was released and was detected in the offsite areas almost due south of surface zero as shown in figure 2.

Measurements made by ground monitors at the junction of Highway 95 and State Road 16 increased from 0.5 mR/h above background at 0655 hours Pdt to 0.7 mR/h at 0700 hours, and by 0800 hours dropped to 0.03 mR/h. Ground monitors at Death Valley Junction and Shoshone, Calif., measured 0.01 to 0.03 mR/h above background and exposure rate recorders at the same location showed integrated exposures of about 0.06 mR. This was estimated by manually integrating the area under the trace of exposure rate versus time on the recorder chart. No fresh fission products were detected in milk, water, or vegetation samples.

Aerial surveillance

A PHS Turbo-Beech first made contact with the trailing edge of the cloud at 0805 hours, 13 miles northwest of Death Valley Junction, Calif., at 5,700 feet msl. A spiral descent 12 miles northwest of Death Valley Junction showed gamma activity between 6,300 feet and 5,700 feet msl, with the maximum activity at 6,000 feet. Therefore, the remainder of the mission was flown at that altitude. The peak exposure rate of the mission was 0.03 mR/h at 0830, 4 miles north of Death Valley Junction. The leading edge was located 25 miles south of Shoshone, Calif., at 0951 hours. At 1006 hours the east edge was found to be 4 miles west of Tecopa, Calif. A spiral descent was made 5 miles west of Tecopa at 1017 hours. The cloud top was at 7,500 feet msl and the bottom was

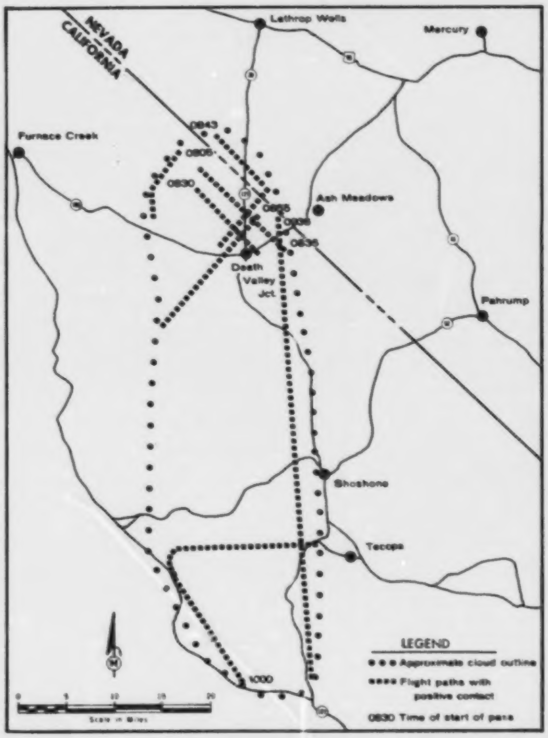
NEVADA
CALIFORNIA
Lathrop Wells
Mercury
Furnace Creek
0843
0805
0830
Ash Meadows
0855
0838
0836
Death Valley Jct
Pahrump
Shoshone
Tecopa
1000
N
0
5
10
15
20
Scale in Miles
LEGEND
● ● ● Approximate cloud outline
●●●● Flight paths with positive contact
0830 Time of start of pass

Figure 3. Aerial surveillance results, Umber Event June 29, 1967

at ground level, 2,000 feet msl. Maximum activity was located at 4,000 feet msl. Figure 3 shows the flight paths along which positive cloud contact was maintained, and the approximate cloud outline. The cloud volume was calculated to be 1.2×10^{12} cubic meters.

A mass air sample was collected during the mission. No activity above background was found on the filter or charcoal bed. A gas sample was collected at 0840 hours. The results of inert gas analysis are presented in table 6. The cloud total in table 6 is not necessarily the product of concentration and cloud volume because the computations are performed with figures containing a greater number of significant digits and are rounded off for reporting purposes.

Table 6. Aerial sample results, Umber Event [a]

Radionuclide	Concentration (pCi/m³)	Total radioactivity in cloud (Ci)
Krypton-85m	3,500	4,400
Krypton-87	350	430
Krypton-88	9,500	12,000
Xenon-135	2,800	3,500

[a] Time of collection—0840 hours, 6/29/67.

Reactor experiments

Phoebus IB

The Phoebus 1B reactor test series consisted of three calibration operations and a full power run. Table 7 lists the operating times and integral power of each of the experiments, all conducted at Test Cell C, NRDS.

Table 7. Phoebus 1B test series data

Experiment	Date (1967)	Approximate power integral (MW)	Radiation detectable off NTS
EP-I	Jan 25-26	2.5	No
EP-II	Feb 2-3	300	No
EP-III	Feb 10 (1311 Pst)	1.5×10^5	Yes
EP-IV	Feb 23 (1400-1430 Pst)	3×10^6	Yes

EP-111 test, February 10, 1967

Ground surveillance

Effluent from the EP-III test was detected offsite by ground monitors, aerial monitors, and air and vegetation sampling. Although no fresh fission products were detected on the vegetation samples, barely detectable levels of iodine-131 on vegetation had been noted about a month before this reactor operation. The source of this iodine is presumed to be from foreign atmospheric nuclear testing. The prefilter taken from a portable air sampler located at Ash Meadows turnoff on Highway 95 showed 28 pCi/m³ of barium-139 which, because of its short half-life, is assumed to have been the result of EP-III effluent.

The only measurement of radioactivity above background was made by ground monitors at the junction of Highway 95 and State Road 16 (Ash Meadows turnoff). This reading was only slightly above background and dropped to background levels within 30 minutes. No fresh fission products were detected in milk or water samples.

Aerial surveillance

A spiral descent by the PHS aircraft of NRDS located the cloud top at 12,300 feet msl, the cloud bottom at 5,800 feet and the altitude of maximum activity at 8,500 feet. A sampling path was established at 8,500 feet along Highway 95. Cloud arrival on this path at the Ash Meadows turnoff, 155° at 20.2 miles from Test Cell C, at 1345 hours established the wind speed as 35 mph. The cloud hotline was on a bearing of 160° from the test cell. The peak dose rate was 0.04 mR/h at 1356 hours. The maximum width was 9.9 miles at 1350 hours. Figure 4 presents the plan view of the cloud as it crossed Highway 95, normalized to 1410 hours. Cloud volume was 6.2×10^{11} cubic meters.

A subsequent axial pass located the trailing edge, 8 miles northwest of Pahrump, Nev. at 1450, with the leading edge 20 miles at 165° from Pahrump. The peak exposure rate measured on this pass was 0.01 mR/h.

Table 8 lists the results from the mass air filter and gas sample. The charcoal bed contained no identifiable fission products. The cloud total in table 8 is not necessarily the product of concentration and cloud volume because the computations are performed with figures containing a greater number of significant digits and are for reporting purposes.

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Table 8. Results from mass air filter and gas sample Phoebus IB, EP–III

Radioactivity	Concentration (pCi/m³)	Cloud total (Curies)
Strontium-91	57	35
Strontium-92	49	30
Molybdenum-99	8.5	5
Barium-139	260	160
Krypton[a]	20,000	13,000
Xenon-135	39	23
Gross beta particulates	530	340

[a] Krypton isotopes were not identified. The activity was extrapolated using an average krypton half-life.

EP-IV test, February 23, 1967

Ground surveillance

The EP–IV test resulted in a release of radioactive effluent which was detected northeast and south of the test range complex. Ground monitors detected two to three times background levels on a scintillation instrument with a background reading of about 0.01 mR/h. These measurements were recorded at Queen City Summit and at a point 4 miles southeast of the summit during cloud passage at 1830-1845 hours. Primary effluent trajectory as shown by air sampling and vegetation sampling, was northwest of Queen City Summit. However, TLD's placed at 2-mile intervals from Hiko to 8 miles northwest of Queen City Summit showed no exposures above normal background.

Three RM–11 recorder stations reported gross gamma exposures twice that of instrument background during cloud passage at 2000 hours and 2030 hours, respectively, at Diablo and Twin Springs. Effluent from reactor pulse-cooling reached Lathrop Wells at about 2030 hours; the maximum reading was less than twice the background value of 0.03 mR/h. Low level night winds, at about 180° from the primary wind direction during daylight hours, caused the pulse-cooling effluent to travel south.

Table 9 lists all the ASN stations where fresh fission products were detected or where gross beta concentrations were above 1 pCi/m³; table 10 lists isotopic results from the six stations where maximum amounts were detected. Tables 11, 12, and 13 list the locations and media of other detected amounts of radioactivity.

Aerial surveillance

Because of the northerly trajectory of the effluent from EP–IV, the primary cloud sampling was performed onsite. Three tracking missions were performed, one on run day and two the following day. Four large-volume tracking filter samples were collected on the first tracking mission. Two to six short-term sam-

Table 9. ASN stations showing gross beta concentrations in excess of 1 pCi/m³, Phoebus, 1B EP–IV

Location	February 23rd	February 24th	Gross beta radioactivity		February 24th	February 25th	Gross beta radioactivity	
	Time on	Time off	(pCi/m³)	(pCi-h/m³)	Time on	Time off	(pCi/m³)	(pCi-h/m³)
Beatty, Nev	0805	0723	[a]1.0	23	0725	0720	[b]1.1	26
Current, Nev	0715	0715	[b]1.4	34	—	—	—	—
Death Valley Jct., Calif	0645	0645	[a]5.7	140	—	—	—	—
Diablo, Nev	0640	0645	[a]170	4,000	0645	0700	2.5	60
Twin Springs, Nev	0930	0845	[a]2.3	54	0845	0945	1.6	40
Lathrop Wells, Nev	0850	1605	[a]230	7,200	—	—	—	—
Shoshone, Calif	1245	1317	[c]2.4	59	—	—	—	—
Warm Springs, Nev	0900	0900	[a]41	980	0900	0900	[b]6.0	140
Eureka, Nev	1950	0730	[a]71	850	0730	0730	[a]7.2	170
Blue Jay, Nev	0730	0725	[b]52	1,200	0725	0835	[c]13	330
Elko, Nev	1326	1310	1.2	28	1310	1237	[a]1.2	28
Nyala, Nev	0800	0800	[b]5.9	140	0800	0800	6.0	[d]95
Boise, Idaho	—	—	—	—	0840	1100	2.2	58
Wells, Nev	1701	1704	[c]2.2	53	—	—	—	—
Clark Station, Nev	0655	0700	[a]1.7	41	0700	0710	[a]1.4	33
Goss Ranch, Nev	1640	1200	[a]34	650	([e])	([e])	([e])	([e])
Queen City Summit, Nev. (unpopulated)	1705	1230	1.1	21	([e])	([e])	([e])	([e])
Bozeman, Mont	—	—	—	—	1110	1050	1.1	26
12 miles west of Coyote Summit, Nev	1645	[f]2051	[b]49	200	([e])	([e])	([e])	([e])

[a] Radioiodines on both prefilter and charcoal cartridge.
[b] Radioiodines found on prefilter only.
[c] Charcoal cartridge was not in use.
[d] Sampler was operated for 15.9 hours during this period.
[e] Not operated—temporary sampler.
[f] Samples removed at 2051, February 23, 1967.

Note: Integrated concentrations are calculated using the elapsed time as shown on the timer attached to the air sampler. The times shown in column 2 are clock times as noted by the station operator.

Table 10. Isotopic air results from the six stations having the highest concentrations,[a] Phoebus, 1B EP–IV

Location in Nevada	Time on and date	Time off and date	Sample volume (m³)	Collector[b]	Prefilter gross beta radioactivity		Iodine-131		Tellurium-iodine-132		Iodine-131		Iodine-135		Cerium-141	
					(pCi/m³)	(pCi-h/m³)	(pCi/m³)	(pCi-h/m³)	(pCi/m³)	(pCi-h/m³)	(pCi/m³)	(pCi-h/m³)	(pCi/m³)	(pCi-h/m³)	(pCi/m³)	(pCi-h/m³)
Lathrop Wells	0850	1605	662	P			15	470	140	4,400	5.8	180	ND	—	83	2,600
	2/23	2/24		C	230	7,100	12	390	4.5	140	68	2,100	ND	—	71	2,200
Diablo	0640	0645	511	P			14	240	48	1,100	57	1,300	ND	—	ND	—
	2/23	2/24		C	170	4,000	19	440	22	510	72	1,700	24	570	ND	—
Blue Jay	0730	0725	505	P			4.7	110	15	360	16	380	ND	—	6.7	160
	2/23	2/24		C	52	1,200	ND	—	ND	—	ND	—	ND	—	ND	—
Blue Jay	0725	0835	520	P			3.1	78	11	280	8.2	210	ND	—	2.3	58
	2/24	2/25		no C	13	330										
Warm Springs	0900	0900	485	P			4.4	110	14	340	20	480	71	1,700	ND	—
	2/23	2/24		C	41	970	6.4	150	6.8	160	29	700	ND	—	ND	—
Warm Springs	0900	0900	485	P	6.0	140	1.4	34	5.2	120	3.8	91	ND	—	1.9	46
	2/24	2/25		C			ND	—	ND	—	ND	—	ND	—	ND	—
Eureka	1950	0730	249	P			7.2	86	23	270	35	420	180	2,100	ND	—
	2/23	2/24		C	71	850	11	130	12	140	16	190	ND	—	ND	—
Eureka	0730	0730	497	P			1.5	36	5.3	130	4.2	100	ND	—	1.1	26
	2/24	2/25		C	7.2	170	2.6	62	2.8	67	8.2	200	ND	—	.4	10
Goss Ranch, 23 miles south of Diablo	1640	1200	203	P			2.4	46	8.0	150	6.2	120	8.7	170	2.6	50
	2/23	2/24		C	34	660	4.0	77	3.0	58	7.7	150	3.0	58	ND	—

[a] Integrated concentrations are calculated using the elapsed time as shown on the timer attached to the air sampler. The times shown in column 2 are clock times as noted by the station operator.

[b] P, prefilter, C, charcoal cartridge.

ND, nondetectable.

Table 11. Vegetation samples containing detectable fresh fission products, Phoebus 1B EP–IV

Location in Nevada	Date collected
Alamo	2/24
20 miles south of Beatty	2/24
25 miles south of Beatty	2/24
Springdale	2/24
5 miles west of Lathrop Wells	2/24
Selbach Ranch (Lathrop Wells)[a]	2/24
5 miles east of Coyote Summit	2/24
10 miles northwest of Queen City Summit	2/24
15 miles northwest of Queen City Summit	2/24
Warm Springs	2/24
20 miles northwest of Queen City Summit	2/24
25 miles northwest of Queen City Summit	2/24
30 miles northwest of Queen City Summit	2/24
35 miles northwest of Queen City Summit	2/24
40 miles northwest of Queen City Summit	2/24
Bradshaw Ranch (Duckwater)[a]	2/28
Segura Ranch (Eureka)[a]	3/1
Gardners Ranch (Preston)[a]	2/28
Cold Creek Ranch (Strawberry)[a]	3/1

[a] Nearest map location.

Table 12. Water sampling results, Phoebus 1B EP–IV

Location	Source	Date collected	Gross beta radioactivity (pCi/liter)
Triple T Ranch Austin, Nev	Pond	2/25	3
Cummings Ranch Baker, Nev	Pond	2/25	2
Blue Eagle Ranch Currant, Nev	Spring	2/26	6
Currant Creek Reservoir, Nev	Pond	2/24	3
Diablo, Nev	Tap	2/26	10
Bradshaw Ranch Duckwater, Nev	Tap	2/25	14
M. Gardner Dairy Lund, Nev	Tap	2/25	4
W. Gardner Dairy Lund, Nev	Tap	2/25	3
McKenzie Dairy Lund, Nev	Tap	2/25	ND
Scow Dairy Lund, Nev	Tap	2/25	3
Yelland Ranch McGill, Nev	Stream	2/25	1
Yelland Ranch McGill, Nev	Stream	2/26	2
Fallini's Pond Twin Springs, Nev	Pond	2/24	72
Fallini's Pond Twin Springs, Nev	Pond	2/26	63
Pruess Reservoir Garrison, Utah	Pond	2/25	13

ND, nondetectable.

ples were collected simultaneously with each tracking filter sample. Sampling locations and times are shown in figure 5. Table 14 gives the radionuclide concentrations as determined from the tracking samples.

The second tracking flight started at NRDS at 0744 hours on February 24. This flight proceeded to the vicinity of Malad City, Idaho, then back to Elko, Nev. Four tracking filters were collected for 40-minute sampling periods.

Table 13. Four highest iodine-131 concentrations in milk samples, Phoebus 1B EP-IV

Location	Date of milking (1967)	Radionuclide concentration (pCi/liter)				
		Iodine-131	Iodine-133	Iodine-137	Strontium-89	Strontium-90
Martin Ranch, Eureka, Nev	2/28 am	60	ND	30	ND	14
Ideal Dairy, Richfield, Utah	2/27 pm	40	ND	20	ND	7.8
Martin Ranch, Eureka, Nev	2/24 am	20	50	40	ND	16
Cammack Dairy, Blackfoot, Idaho	2/25 am	20	ND	20	ND	6.7

ND, nondetectable.

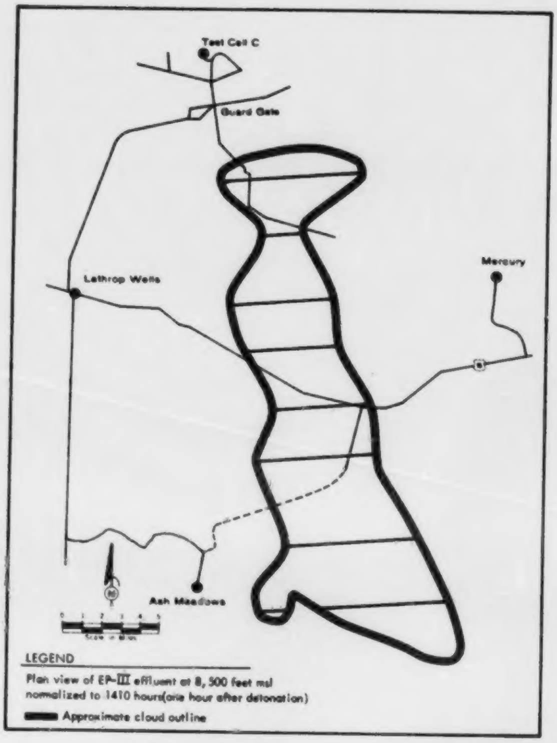
Test Cell C
Guard Gate
Mercury
Lathrop Wells
Ash Meadows
0 1 2 3 4 5
Scale in Miles
LEGEND
Plan view of EP-III effluent at 8,500 feet msl normalized to 1410 hours(one hour after detonation)
Approximate cloud outline

Figure 4. Aerial surveillance results, Phoebus 1B, EP-III

Four 10-minute interval samples were collected with each 40-minute tracking filter and were immediately counted for beta radioactivity. Sample volumes and radionuclide concentrations for tracking filters three and four are based on the sampling time during which positive external gamma activity was detected by a 4- by 4-inch NaI(T1) crystal detector. Sample volumes for filters one and two are based on the total sample time as no indications above background were seen during their collection. Tracking filter results are given in table 15.

A third tracking mission was also flown on February 24. This mission covered the area from Salt Lake City, Utah, to Dubois, Idaho. Two 40-minute tracking filters were collected. Four 10-minute interval filters were collected with each tracking filter. The results of these tracking filters are also shown in table 15 as filters five and six.

Figure 6 shows the paths of the tracking flights and location of tracking filter sample collections.

As shown in figure 7, fresh fission products were detected in all directions from Test Cell "C," excepting the 110° to 170° sector. Though

Table 14. Tracking filter results, Phoebus 1B, EP-IV, February 23, 1967

Filter number	Time interval	Volume (m^3)	Radionuclide concentration (pCi/m^3 at mid-time of collection)						
			Strontium-91	Zirconium-97	Molybdenum-99	Tellurium-132	Iodine-131	Iodine-133	Iodine-135
1	1909–1954	50	ND	120	46	150	50	840	670
2	1959–2020	92	ND	67	50	190	74	880	880
3	2106–2109	57	880	ND	74	320	88	1,300	1,000
4	2113–2123	190	1,400	ND	150	780	210	270	2,500

ND, nondetectable.

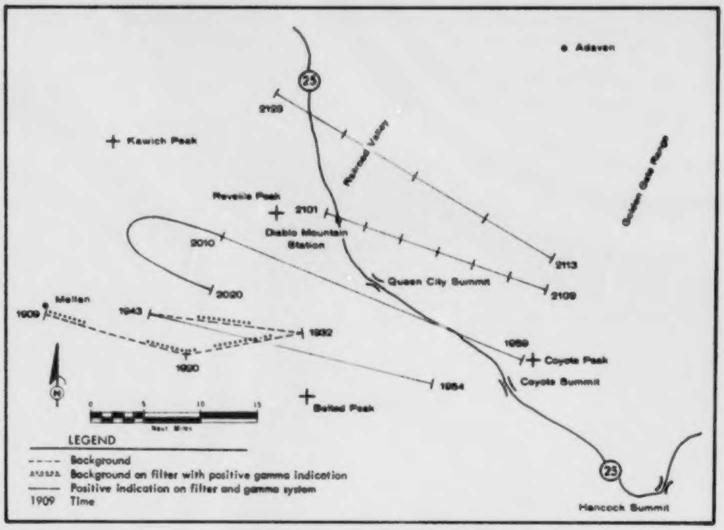
Adaven
25
2120
Kawich Peak
Railroad Valley
Golden Gate Range
Reveille Peak
2101
Diablo Mountain Station
2010
2113
Queen City Summit
2109
2020
Mellan
1909
1943
1932
1920
1959
Coyote Peak
Coyote Summit
1954
N
0
5
10
15
Naut. Miles
Belted Peak
LEGEND
Background
Background on filter with positive gamma indication
Positive indication on filter and gamma system
1909 Time
25
Hancock Summit

Figure 5. Tracking flight no. 1 showing time, Phoebus 1B, EP-IV February 23, 1967

Table 15. Tracking filter results, Phoebus 1B, EP-IV, February 24, 1967

Filter number	Time interval	Volume (m³)	Radionuclide concentration (pCi/m³ at mid-time of collection)				
			Zirconium-97	Molybdenum-99	Tellurium-132	Iodine-131	Iodine-133
1	0744–0828	193	ND	ND	ND	ND	2.8
2	0831–0913	185	ND	0.35	0.70	ND	1.8
3	0917–0958	[a]45	ND	4.9	1.8	6.4	67
4	1004–1045	[a]135	ND	1.8	5.7	1.8	22
5	1630–1710	[a]66	2.8	6.4	12	4.2	30
6	1715–1812	[a]150	ND	.70	2.5	.70	6.0

[a] Volume based on time during which activity was detected by a 4- by 4-inch crystal.
ND, nondetectable.

Table 16. The 10 high air concentrations of gross beta radioactivity resulting from reactor tests conducted during period, January 1-June 30, 1967

Location in Nevada	Date and time on	Date and time off	Duration (h)	Volume (m³)	Collector[a]	Gross beta concentration	
						(pCi/m³)	(pCi-h/m³)[b]
Jct. Highway 95 and Highway 16	2/10 1330	2/10 1530	2.0	20.7	P	260	520
Lathrop Wells	2/23 0850	2/24 1605	31.2	662	P	230	7,200
Diablo	2/23 0640	2/24 0645	23.5	511	P	170	4,000
Eureka	2/23 1950	2/24 0730	12.0	249	P	71	850
Blue Jay	2/23 0730	2/24 0725	23.8	505	P	52	1,200
Warm Springs	2/23 0900	2/24 0900	24.0	485	P	41	980
Goss Ranch	2/23 1640	2/24 1200	19.2	203	P	34	650
Blue Jay	2/24 0725	2/25 0835	25.1	520	P	14	350
Eureka	2/24 0730	2/25 0730	24.0	497	P	7.2	170
Nyala	2/24 0800	2/25 0800	15.9	346	P	6.0	95

[a] P, prefilter.
[b] Sample pCi divided by sample rate.

12b

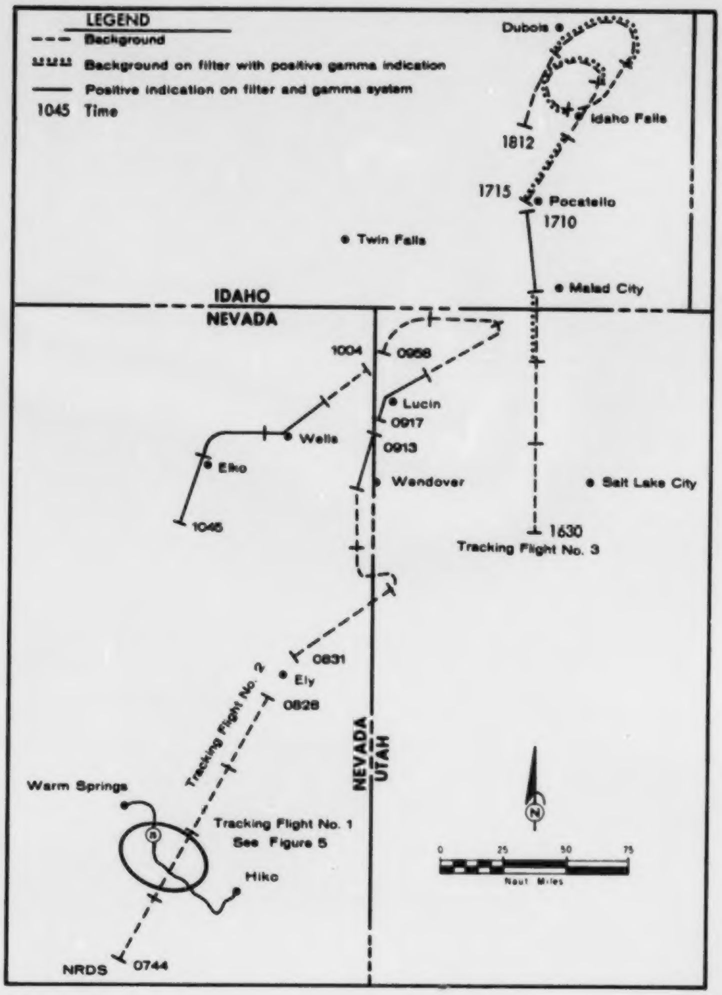
LEGEND
Background
Background on filter with positive gamma indication
Positive indication on filter and gamma system
1045 Time
Dubois
Idaho Falls
1812
1715
Pocatello
1710
Twin Falls
Malad City
IDAHO
NEVADA
1004
0958
Lucin
0917
0913
Wells
Elko
1045
Wendover
Salt Lake City
1630
Tracking Flight No. 3
0831
Ely
0828
Tracking Flight No. 2
NEVADA
UTAH
Warm Springs
Tracking Flight No. 1
See Figure 5
Hiko
NRDS
0744
N
0
25
50
75
Naut. Miles

Figure 6. Tracking flights, Phoebus IB, EP-IV, February 24, 1967

the main portion of the cloud moved north to northeast, the above normal gross beta concentration recorded at Boise, Idaho, suggests a cloud movement closer to true north. Fresh fission products were also carried to the south-southwest by low-level drainage winds on the night of February 23, and on the morning of February 24 the wind changed directions moving northwest over Beatty and Goldfield.

Although it is possible that small amounts of iodine-131 were residual on pastures from a foreign test conducted in December 1966, the source of all fresh fission products found in any environmental samples collected during this period is assumed to be the result of the EP–IV operation.

127

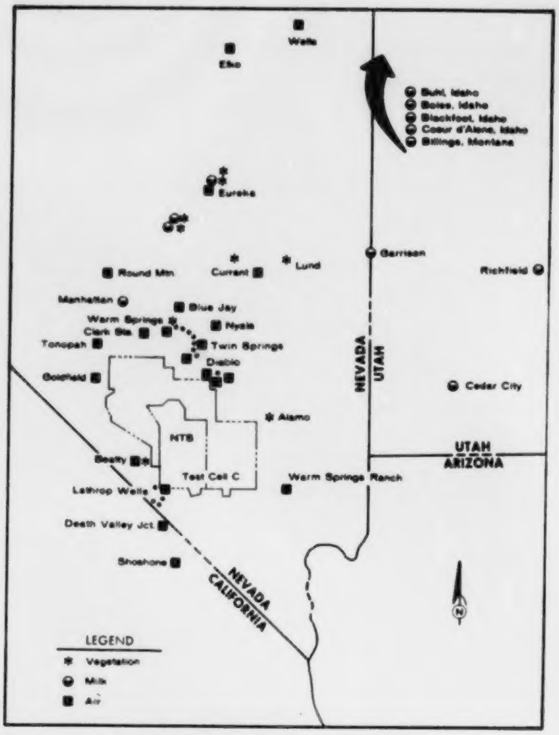
Wells
Elko
Buhl, Idaho
Boise, Idaho
Blackfoot, Idaho
Coeur d'Alene, Idaho
Billings, Montana
Eureka
Garrison
Richfield
Round Mtn
Currant
Lund
Manhattan
Blue Jay
Warm Springs
Clark Sta.
Nyala
Tonopah
Twin Springs
Diablo
Goldfield
NEVADA
UTAH
Cedar City
Alamo
NTS
Beatty
Test Cell C
Lathrop Wells
Warm Springs Ranch
UTAH
ARIZONA
Death Valley Jct
Shoshone
NEVADA
CALIFORNIA
N
LEGEND
Vegetation
Milk
Air

Figure 7. Locations where fresh fission products were detected

Table 17. Ten high gross beta concentrations on air samples for early January 1967 from a Chinese atmospheric nuclear test

Location	Date and time on	Date and time off	Gross beta concentrations (pCi/m³)
Clark Station, Nev	1/01 0830	1/02 0805	210
Lovelock, Nev	1/01 0930	1/02 0900	190
Warm Springs, Nev	1/01 0900	1/02 0900	180
Round Mountain, Nev	1/01 1236	1/02 1212	180
Reno, Nev	1/01 0740	1/02 0805	150
Currant, Nev	1/01 0730	1/02 0730	150
Frenchman, Nev	1/01 0849	1/02 0815	150
Bryce, Utah	1/01 0755	1/02 0756	150
Nyala, Nev	1/01 0800	1/02 0800	150
Lida, Nev	1/01 0955	1/02 0710	130

Summary

Results of offsite surveillance activities, including listings of the highest concentrations of gross beta activity and iodine-131 are summarized in tables 16 through 19. Gross beta results on air filters collected following weapons tests during this period did not exceed 3 pCi/m³.

Though gross beta activity in the air has little value in determining radiation exposures to persons, indications of airborne radioactivity present in a specific area aid in determining where milk, water, and vegetation samples should be collected.

Table 18. Ten high iodine-131 concentrations in air resulting from reactor tests, January-June 30, 1967

Locations in Nevada	Date and time on	Date and time off	Duration (h)	Volume (m³)	Collector[a]	Iodine-131 beta concentrations	
						(pCi/m³)	(pCi-h/m³)[b]
Diablo	2/23 0640	2/24 0645	23.5	511	C	18.9	444
Lathrop Wells	2/23 0850	2/24 1605	31.2	662	P	15.2	475
Diablo	2/23 0640	2/24 0645	23.5	511	P	14.0	329
Lathrop Wells	2/23 0850	2/24 1605	31.2	662	C	12.4	387
Eureka	2/23 1950	2/24 0730	11.6	249	C	10.7	128
Eureka	2/23 1950	2/24 0730	11.6	249	P	7.2	86.4
Warm Springs	2/23 0900	2/24 0900	24.0	485	C	6.4	153
Blue Jay	2/23 0730	2/24 0725	23.8	505	P	4.7	113
Warm Springs	2/23 0900	2/24 0900	24.0	485	P	4.4	106
Coyote Summit, Goss Ranch	2/23 1640	2/24 1200	19.2	203	C	4.0	76.8

[a] P, prefilter; C, charcoal cartridge.
[b] Sample pCi divided by sample rate.

Table 19. Thirteen high concentrations of iodine-131 in milk samples collected from January 1, 1967-July 1, 1967

Location	Date (1967)	Iodine-131 (pCi/liter)
Spanish Fork, Utah—Town Pride Dairy	1/05	90
Spanish Fork, Utah—Town Pride Dairy	1/06	90
Eureka, Nev.—Martin Ranch	2/28	60
Springdale, Nev.—Peacock Ranch	1/04	60
Spanish Fork, Utah—Town Pride	1/07	50
Ogden, Utah—Maple Leaf Dairy	1/11	40
Nyala, Nev.—Sharp's Ranch	1/10	40
Richfield, Utah—Ideal Dairy	2/27	40
Buhl, Idaho—Smith Dairy	1/06	30
Mt. Pleasant, Utah—Brooklawn Creamery	1/08	30
Mt. Pleasant, Utah—Brooklawn Creamery	1/12	30
Smithfield, Utah—Cache Valley Dairy	1/05	30
Smithfield, Utah—Cache Valley Dairy	1/10	30

The source of all levels of radioactivity measured offsite during this period was predominantly the two reactor tests discussed and a Chinese atmospheric nuclear detonation on December 27, 1966.

Conclusion

Results obtained through environmental radiation surveillance during this period indicate that no individual in the offsite area received an exposure, resulting from Nevada Test Site or NRDS operations, which exceeded the radiological safety criteria established by the AEC (*1*).

REFERENCE:

(*1*) U.S. ATOMIC ENERGY COMMISSION. U.S. Atomic Energy Commission Rules and Regulations, Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation.

Strontium-90 in Human Bone, April-June 1971 [1]

Office of Radiation Programs
Environmental Protection Agency

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

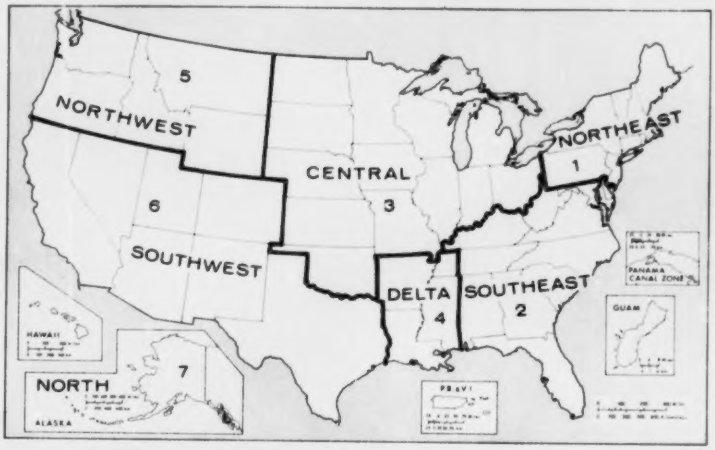

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, April-June 1971

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
New York	V, R, F	0	M	13.2 ± 4.8	19.2	0.69
	V, R, I	0	F	57.8 ± 9.4	27.3	2.12
	V, R	0	M	32.1 ± 8.6	31.6	1.02
	V	3	M	46.2 ±10.1	31.8	1.45
	V	5	F	45.6 ± 6.0	27.5	1.66
Pennsylvania	V	8	M	35.8 ± 6.2	20.2	1.77
New Jersey	V	8	F	35.9 ± 6.1	27.5	1.30
New York	V	9	F	68.2 ± 9.5	32.8	2.08
	V	11	M	73.1 ± 8.5	35.8	2.04
	V	12	M	53.1 ± 8.3	32.3	1.64
	V	14	M	47.7 ± 8.6	38.3	1.25
	V	19	M	57.8 ± 9.9	54.1	1.07
	V	19	M	85.6 ± 9.3	44.9	1.90
	V	20	M	75.8 ± 8.5	46.0	1.65
	V	21	F	109.2 ± 9.8	49.5	2.20
	V	23	M	56.4 ± 6.6	46.6	1.21
New Jersey	V	24	M	52.1 ± 6.8	43.9	1.19
Pennsylvania	V, R, I	24	M	73.8 ±11.4	61.8	1.19
New York	V	24	M	23.8 ± 6.5	35.9	.66
	V	25	M	60.9 ± 7.6	39.0	1.56
Pennsylvania	V	25	M	66.1 ±10.5	56.0	1.18
Southeast:						
Maryland	V	2	M	78.8 ±11.7	33.1	2.38
	V	2	M	59.2 ±10.0	31.7	1.87
	V	5	M	60.1 ±10.9	39.5	1.52
South Carolina	V	6	M	77.5 ± 7.2	27.3	2.84
	V	13	M	84.7 ± 8.9	40.9	2.07
Georgia	V	13	F	65.1 ± 7.8	39.5	1.65
Maryland	V	14	F	94.0 ±12.3	53.7	1.75
	V	16	M	100.8 ±10.8	48.4	2.08
	V	17	M	121.2 ±10.5	68.0	1.78
South Carolina	V	17	M	150.0 ±12.2	65.7	2.28
Maryland	V	17	M	90.4 ± 9.8	55.1	1.64
	V	17	M	81.3 ±10.4	51.2	1.59
South Carolina	V	17	M	81.5 ± 7.8	41.1	1.98
Maryland	V	17	M	110.7 ±12.0	52.5	2.11
	V	18	F	57.7 ± 8.0	50.2	1.15
	V	18	M	82.8 ± 7.6	47.5	1.74
South Carolina	V	18	F	130.0 ±11.4	41.4	3.14
Maryland	V	18	M	73.3 ± 8.6	58.2	1.26
	V	18	M	120.8 ±10.3	51.1	2.36
	V	18	F	66.1 ± 7.8	51.4	1.29
South Carolina	V	19	M	134.4 ± 8.8	38.2	3.52
Maryland	V	19	M	96.8 ±10.3	51.5	1.88
South Carolina	V	19	M	65.7 ± 6.6	46.4	1.42
Maryland	V	19	M	127.3 ± 9.9	59.3	2.15
	V	19	M	93.5 ±13.1	59.8	1.56
	V	19	F	77.2 ±12.6	54.4	1.42
	V	20	F	64.9 ±10.1	49.8	1.30
Virginia	V	20	F	108.2 ±10.8	44.4	2.44
Maryland	V	20	F	90.3 ±11.3	49.9	1.81
	V	20	M	118.0 ±12.4	56.4	2.09
	V	20	M	100.2 ±11.9	46.4	2.16
	V	20	M	99.0 ±11.1	54.7	1.81
	V	21	M	53.5 ± 9.5	47.4	1.13
	V	21	M	122.3 ±11.5	60.0	2.04
	V	21	M	67.8 ± 7.6	57.1	1.19
Tennessee	V	21	F	80.5 ± 8.7	44.1	1.83
Maryland	V	21	F	69.5 ± 9.6	48.6	1.43
	V	22	M	99.4 ±12.5	64.4	1.54
	V	22	M	73.5 ± 8.8	49.0	1.50
D.C	V	22	M	106.0 ±10.4	53.7	1.97
Maryland	V	22	M	62.9 ± 9.0	39.6	1.59
	V	22	M	113.6 ± 9.7	57.0	1.99
	V	23	M	74.3 ±10.1	51.1	1.46
	V	23	M	58.6 ± 8.4	49.6	1.18
	V	23	F	47.3 ± 8.8	42.0	1.13
Tennessee	V	24	M	32.5 ± 5.7	44.2	.74
Maryland	V	24	M	81.8 ±10.5	46.3	1.76
	V	24	M	51.3 ± 6.6	53.0	.97
Virginia	V	24	M	55.9 ± 7.3	44.8	1.25
Maryland	V	25	M	82.7 ± 9.7	55.0	1.50
	V	25	M	75.1 ± 8.7	57.2	1.31
	V	25	F	67.6 ± 8.1	49.2	1.37
	V	25	M	64.3 ± 8.3	49.4	1.30
	V	25	M	66.3 ± 9.6	54.6	1.21
	V	25	M	71.7 ± 8.4	46.6	1.54
Central:						
Ohio	V	3	M	80.6 ±10.3	28.3	2.85
Wisconsin	V	4	M	43.4 ± 6.4	29.2	1.49
Iowa	V	4	M	63.6 ± 6.9	29.5	2.15
Wisconsin	V	8	F	81.5 ± 6.9	39.2	2.08
Ohio	V	10	F	70.8 ±10.1	45.5	1.56
Michigan	V	10	F	94.6 ±10.1	48.0	1.97
Wisconsin	V	10	M	39.4 ± 5.6	28.7	1.37
	V	13	F	102.0 ± 9.2	40.4	2.52
Minnesota	V	14	M	89.0 ± 8.2	42.1	2.11

See footnotes at end of table.

Table 1. Strontium-90 in human bone, April-June 1971—continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Central:						
Ohio	V	14	M	68.6 ± 7.6	40.3	1.70
Wisconsin	V	14	M	54.4 ± 6.7	42.7	1.27
Ohio	V	15	M	75.6 ± 10.8	56.3	1.34
	V	16	M	62.1 ± 11.4	72.8	.85
	V	16	M	158.2 ± 13.5	58.8	2.69
	V	16	F	62.1 ± 6.9	49.1	1.26
	V	16	M	46.6 ± 7.5	34.9	1.33
	V	17	F	72.6 ± 8.8	45.3	1.60
	V	17	M	159.4 ± 14.0	59.0	2.70
	V	17	M	90.0 ± 11.4	44.8	2.01
Minnesota	V	17	M	63.6 ± 7.4	40.0	1.59
Ohio	V	18	M	54.8 ± 7.1	49.3	1.11
	V	18	F	91.7 ± 10.0	52.6	1.74
	V	18	M	95.2 ± 12.2	58.1	1.64
	V	19	M	70.9 ± 6.9	48.3	1.47
	V	19	M	77.7 ± 8.9	55.7	1.40
	V	20	F	132.6 ± 14.2	58.3	2.28
	V	20	M	66.1 ± 9.7	47.4	1.39
	V	21	M	54.9 ± 7.3	38.7	1.42
	V	22	F	122.6 ± 12.9	58.1	2.11
	V	23	F	64.9 ± 10.1	51.4	1.26
	V	23	M	69.8 ± 7.2	47.6	1.47
	V	24	M	65.1 ± 8.5	55.2	1.18
Delta:						
Louisiana	V, R	13	M	118.8 ± 11.5	49.9	2.38
	V, R	15	M	148.4 ± 11.1	58.2	2.55
	V, R	18	M	195.7 ± 19.0	75.6	2.59
	V	23	M	82.8 ± 10.5	49.8	1.66
Northwest:						
Oregon	V	11	F	58.9 ± 6.7	43.0	1.37
	V	15	M	58.8 ± 6.8	37.1	1.58
	V	17	M	44.2 ± 6.4	43.1	1.02
	V	19	F	70.6 ± 7.0	40.9	1.72
	V	19	M	53.8 ± 8.7	45.2	1.19
Washington	V	20	M	49.7 ± 5.9	46.9	1.06
	V	20	M	35.3 ± 5.2	37.1	.95
Oregon	V	22	M	31.4 ± 5.3	45.8	.69
	V	24	M	65.2 ± 8.5	48.5	1.35
Southwest:						
California	V	10	M	43.3 ± 7.2	36.7	1.18

[a] Type of bone, V, vertebrae; R, rib; I, ilium; F, femur.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory, Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the second quarter (April-June) of 1971 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

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Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
April–June 1970	April 1971
July–September 1970	June 1971
October–December 1970	September 1971
January–March 1971	March 1972

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

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(*5*) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for the Argonne National Laboratory and the Brookhaven National Laboratory.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

I. Argonne National Laboratory[2]
January–June 1971

University of Chicago
Lemont, Ill.

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

The radioactivity of particulate matter in air was determined by drawing air through filter paper at a known rate and measuring the radioactivity of the particles collected by the paper. The samples were collected continuously at nine locations on the Argonne site and at six locations off the site. At one location on the site, the filter paper was changed daily; at all other locations the filter papers were changed at weekly intervals. The daily samples record short-term changes in radioactivity, and the weekly samples are used to compare onsite and offsite

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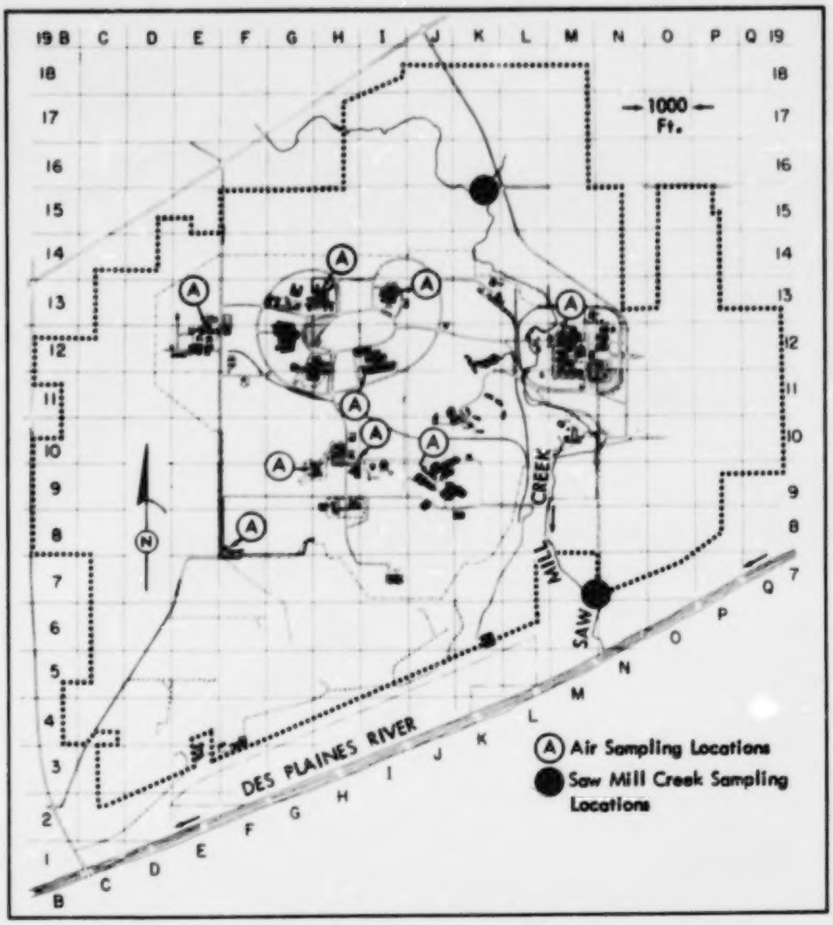
[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January-June 1971," University of Chicago, Lemont, Ill.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Air Sampling Locations
Saw Mill Creek Sampling Locations

Figure 1. Onsite sampling locations at Argonne National Laboratory

radioactivity. The alpha and beta radioactivity in air-filter samples are summarized in table 1; the average concentration of gamma-ray emitters as determined by gamma ray spectrometry are summarized in table 2.

The levels of alpha and beta radioactivities, and those gamma-ray emitters that were found at all locations, were similar on and off the site, indicating that Argonne did not add significantly to the airborne particulate activity of the environment during this period and that these radioactivities originated in a widespread source, such as fallout from nuclear detonations or naturally-occurring materials, and not in a localized source such as the laboratory. Higher activities on the site are indicative of radioactivity released by Argonne, if the differences are greater than the 10 to 20 percent error in sampling and counting. Very small amounts of barium-lanthanum-140 and cobalt-60 (up to 0.0003 percent and 0.02 percent, respectively, of the AEC standard for uncontrolled areas) were detected in March, April, and May at one air sampling location on the laboratory site and were the result of Argonne operations. These two nuclides were not detected off the site; the detection limits are less than 0.0003 percent of the AEC standard. Iodine-131 was present at very low concentrations in samples collected during the first 2 weeks in January both on

Table 1. Alpha and beta radioactivity in air-filter samples,[a] Argonne National Laboratory, January-June 1971

Period	Location	Number of samples	Alpha radioactivity (fCi/m^3)			Beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average	Maximum	Minimum	Average
January	Onsite	26	5.1	2.2	3.4	0.14	0.068	0.097
	Offsite	28	4.9	1.8	3.3	.13	.070	.097
February	Onsite	26	3.7	.6	2.1	.16	.072	.12
	Offsite	24	4.3	1.3	2.5	.18	.072	.12
March	Onsite	31	5.4	.8	2.2	.38	.099	.20
	Offsite	26	4.7	.12	2.2	.38	.12	.22
April	Onsite	30	9.0	1.8	4.9	.75	.14	.46
	Offsite	26	7.0	1.9	4.1	.76	.20	.47
May	Onsite	32	6.4	2.0	3.7	1.2	.45	.76
	Offsite	22	6.1	1.7	3.6	.98	.50	.77
June	Onsite	34	8.1	1.2	4.0	1.0	.42	.64
	Offsite	25	5.5	1.7	3.6	.80	.49	.64
Summary	Onsite	179	9.0	0.6	3.4	1.2	0.068	0.38
	Offsite	151	7.0	1.2	3.2	0.98	0.070	0.39

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Table 2. Gamma-ray radioactivity in air-filter samples, Argonne National Laboratory, January-June 1971

Radionuclide	Location	Concentration[a] (pCi/m^3)						January-June summary
		January	February	March	April	May	June	
Antimony-125	Onsite	<0.001	0.001	0.003	0.004	0.008	0.006	0.004
	Offsite	<.001	.001	.003	.005	.007	.007	.004
Barium-lanthanum-140	Onsite	<.001	<.001	.003	<.001	<.001	<.001	<.001
	Offsite	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Beryllium-7	Onsite	.071	.078	.088	.12	.13	.12	.10
	Offsite	.068	.076	.094	.12	.12	.11	.10
Cerium-141	Onsite	<.001	.002	.004	.009	.010	.006	.005
	Offsite	<.001	.002	.004	.009	.009	.005	.005
Cerium-144	Onsite	.014	.018	.032	.079	.13	.14	.07
	Offsite	.014	.017	.033	.077	.12	.13	.07
Cesium-137	Onsite	.002	.002	.003	.006	.010	.010	.005
	Offsite	.002	.002	.003	.006	.009	.009	.005
Cobalt-60	Onsite	<.001	<.001	.005	.010	.001	<.001	.003
	Offsite	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Iodine-131	Onsite	.01	<.01	<.01	<.01	<.01	<.01	<.01
	Offsite	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Maganese-54	Onsite	<.001	<.001	<.001	.001	.001	.001	<.001
	Offsite	<.001	<.001	<.001	.001	.001	.001	<.001
Ruthenium-103	Onsite	.003	.005	.012	.029	.033	.025	.018
	Offsite	.003	.005	.012	.029	.032	.022	.017
Ruthenium-rhodium-106	Onsite	.016	.018	.025	.053	.088	.095	.049
	Offsite	.017	.020	.032	.056	.081	.085	.049
Zirconium-niobium-95	Onsite	.009	.024	.068	.20	.30	.29	.15
	Offsite	.009	.026	.068	.20	.29	.26	.14

[a] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

Table 3. Argon-41 concentrations, near CP-5 Reactor, January-June 1971

Month	Number of samples	Number of samples >20 nCi/m^3	Concentration[a] (nCi/m^3)		Percent of AEC standard	
			Maximum	Average	Maximum	Average
January	36	7	300	35	750	88
February	32	10	218	42	545	105
March	38	14	400	73	1,000	182
April	34	9	495	49	1,240	122
May	32	14	1,110	69	2,780	172
June	16	2	428	37	1,070	92
Summary	188	56	1,110	51	2,780	127

[a] Minimum detectable concentration—20 nCi/m^3.

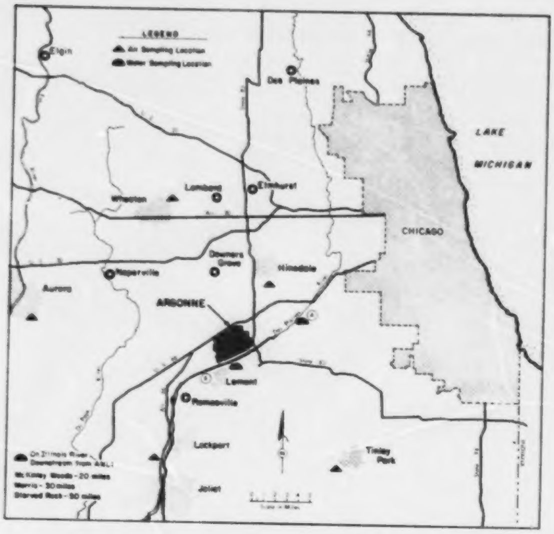

Figure 2. Location of Argonne National Laboratory (including some offsite sampling locations)

and off the site, although only the onsite monthly average was greater than the detection limit. This iodine was due to fallout from nuclear tests conducted late in 1970.

The alpha radioactivity concentrations were normal and in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-fourth of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium-7, produced in the stratosphere by cosmic-ray interactions. The concentrations of total beta radioactivity and of all the gamma-ray emitters for which positive results were obtained, except barium-lanthanum-140 and cobalt-60, increased steadily from January to May. This variation was probably due to the increased stratospheric fallout usually observed in the spring. The very low concentrations of short-lived fission products and the sharp increase in 40-day half-life ruthenium-103 and 65-day half-life zirconium-95 in the spring and imply that most of the fission products were produced late in 1970 and were injected into the atmosphere at high altitudes. The average beta radioactivity for January-June 1971 was about 30 percent greater than in the corresponding period for 1970, primarily because of increased zirconium-niobium-95 concentrations.

The same fission products detected in the air filter samples also were present in precipitation samples, and the beta and gamma radioactivity in these samples also increased during the spring months. Large volume rain samples were collected monthly and analyzed for iron-55. The average monthly concentrations ranged from <2.3 to 15 pCi/m^2 of surface, about 20 times less than 1970 values. Iron-55 is a neutron activation product and was produced mainly in nuclear tests conducted in September and October 1961. Therefore, the above concentrations have been corrected for decay to October 15, 1961, for comparison purposes. Iron-55 concentrations have been decreased to the point where their measurements can be discontinued, and work will be replaced by other more important measurements.

Air also was sampled continuously for radioiodine with activated charcoal in the 200 and 300 Areas because of the possibility of iodine releases in these areas. No iodine radioactivity was detected at either location.

Air sampling for argon-41 (a beta-particle emitter with a 1.8 hour half-life that is produced in an operating reactor by the action of neutrons on the stable argon-40 in air) was conducted near the CP-5 reactor (building 330). The results are tabulated in table 3. These concentrations are based on 1-minute grab samples taken at a position downwind from the reactor at a point favorable for argon-41 detection after the reactor has been in operation for several hours. Therefore, the actual average concentrations in the vicinity of the reactor were much less than the values in the table. The average and maximum concentrations were about 1.3 and 28 times the AEC standard for uncontrolled areas and 0.026 and 0.6 times the AEC standard for controlled areas, respectively. In this case, comparison with the latter standard is appropriate because the measurements were made on the site

Air was sampled for tritiated (hydrogen-3) water vapor, 46 meters (50 yards) east of the CP–5 reactor in the 300 Area, and 183 meters (200 yards) downwind from the reactor. Each sample was collected over a 48-hour period. The

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Table 4. Tritium concentrations, Argonne National Laboratory, January-June 1971

Date (1971)	300 Area						East Area				Offsite			
	Number of samples	Concentration (pCi/m³)			Percent of AEC standard		Number of samples	Concentration (pCi/m³)			Number of samples	Concentration (pCi/m³)		
		Maximum	Minimum	Average	Minimum	Average		Maximum	Minimum	Average		Maximum	Minimum	Average
January	26	1,130	1.4	213	0.56	0.11	2	2.3	0.55	1.4	2	0.37	0.23	0.23
February	24	1,160	1.8	267	.58	.13	2	5.8	4.3	5.1	3	4.1	1.0	2.2
March	26	1,570	5.7	355	.78	.18	4	5.3	1.3	3.0	4	2.4	1.0	1.6
April	26	1,630	5.9	331	.82	.17	1	2.2	—	—	1	2.0	—	—
May	26	2,150	5.2	234	1.07	.12	2	22	4.2	13	2	7.2	3.6	5.4
June	12	4,080	20.8	847	2.04	.42	1	7.2	—	—	1	9.2	—	—
Summary	140	4,080	1.4	375	2.04	0.19	12	22	0.55	5.0	13	9.2	0.23	3.4

results (table 4) were positive in all cases, although the concentrations were well below the AEC standards. The relative concentrations at the two locations correlated well with wind direction. The average concentration of 375 pCi/m³ is about 30 percent higher than the same period in 1970. Twice a month, air samples were collected in the East Area, 1,830 meters (2,000 yards) from the reactor. The tritium concentration in these samples ranged from 0.55 to 22 pCi/m³ and averaged 5.0 pCi/m³. The East Area samples generally varied in the same manner as the activity in the samples near CP–5 when the prevailing wind direction and velocity were considered. In general, East Area samples were greater than 10 pCi/m³ on days when samples at CP–5 were greater than 100 pCi/m³ and the wind was from the southwest. The correlation is sufficiently good to conclude that most of the tritium in the East Area came from CP–5. In addition, samples were collected twice a month from control points located about 6 miles from the laboratory site. The tritium concentration in these samples ranged from 0.23 to 9.2 pCi/m³ and averaged 3.4 pCi/m³. No correlation between the CP–5 and offsite results could be determined. The offsite concentrations are normal for this region and time and are the result of tritium produced by nuclear detonations and cosmic rays.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a small stream that runs through the Argonne grounds and flows into the Des Plaines River about 450 meters (500 yards) downstream from the wastewater discharge. Sawmill Creek was sampled upstream from the Argonne site and downstream from the wastewater outfall to determine if radioactivity was added to the stream in Argonne wastewater. The sampling locations are shown in figure 2.

Below the wastewater outfall, the creek was usually sampled five times weekly. Since it was impractical to analyze all the samples for all the radionuclides and elements desired, equal portions of the individual samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected twice monthly and usually one sample each month was analyzed for each radionuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during January-June 1971 are given in table 5. The similarity between the concentrations at the two sampling locations indicates that very little nonvolatile alpha or beta radioactivity could have been added to the creek in Argonne wastewater. Although the wastewater contained a small quantity of alpha and beta radioactivity, the concentrations were too low to increase the total activities in the stream. The total alpha radioactivity in the creek samples is significantly lower than during the same period in 1970 because all 1971 water samples were filtered to remove suspended solids. This treatment reduced the alpha radioactivity appreciably, particularly in Sawmill Creek (above the site) and Des Plaines River samples which contain considerable suspended soil with its accompanying natural uranium and thorium.

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Table 5. Nonvolatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory, January-June 1971

Month (1971)	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Maximum	Minimum	Average	Maximum	Minimum	Average
January	Upstream	2	2.7	2.6	2.6	18	11	15
	Downstream	20	1.8	.7	1.2	19	13	15
February	Upstream	2	1.5	1.4	1.4	39	24	32
	Downstream	20	1.3	1.0	1.1	22	11	17
March	Upstream	2	1.7	1.3	1.5	13	11	12
	Downstream	20	2.0	1.5	1.7	14	12	14
April	Upstream	2	1.8	1.4	1.6	18	12	15
	Downstream	25	1.7	1.2	1.5	19	13	15
May	Upstream	2	2.2	1.4	1.8	25	23	24
	Downstream	20	1.7	1.3	1.6	24	17	20
June	Upstream	2	1.2	.58	.89	31	24	28
	Downstream	19	1.3	.81	1.1	29	22	26
January-June summary	Upstream	12	2.7	0.58	1.6	39	11	21
	Downstream	124	2.0	0.72	1.4	29	11	18

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements is summarized in table 6. The concentrations were very low compared to the AEC standards. Comparison of these concentrations with the total alpha radioactivity indicates that most of the alpha radioactivity in the creek was due to uranium. The uranium content attributable to Argonne below the outfall ranged from 0.2 to less than 0.1 pCi/liter, depending on the relative amounts of natural creek and wastewater. The thorium concentrations were normal at both locations. Plutonium was found in one sample taken below the outfall, and was evidently added by Argonne wastewater.

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The normal beta radioactivity is approximately 5 pCi/liter above the site and 3 to 5 pCi/liter below the site, depending on the relative amounts of creek and wastewater. The Argonne contribution to the total nonvolatile beta radioactivity below the outfall during the first half of 1971 is estimated to be approximately 1 pCi/liter, about the same as in 1970. The remaining activity at both locations, 12 pCi/liter, was due to the fallout, which was about 40 percent higher than during 1970.

The results of analysis of Sawmill Creek water for specific beta-emitting nuclides are summarized in table 7. The principal beta-particle emitter added to the creek by Argonne wastewater was tritium. The wastewater increased the tritium content of the creek below the outfall by about a factor of 20. This radionuclide, present as water (HTO), is not included in the total beta activity in table 5 because that activity was determined by evaporating the water and measuring the nonvolatile

Table 6. Alpha-emitting elements in Sawmill Creek water, Argonne National Laboratory, January-June 1971

Element	Location[a]	Number of samples	Concentration[b] (pCi/liter)			Percent of AEC standard	
			Maximum	Minimum	Average	Maximum	Average
Uranium	Upstream	6	2.0	0.66	1.4	0.005	0.004
	Downstream	60	2.2	.96	1.6	.005	.004
Plutonium	Upstream	6	<.05	—	—	<.001	—
	Downstream	60	.16	<.05	<.05	.003	<.001
Thorium	Upstream	6	<.05	—	—	<.003	—
	Downstream	60	<.05	—	—	<.003	—

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

[b] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

Table 7. Beta-emitting radionuclides in Sawmill Creek water, Argonne National Laboratory, January-June 1971

Radionuclide	Location[a]	Number of samples	Beta radioactivity[b] (pCi/liter)			Percent of AEC standard	
			Maximum	Minimum	Average	Maximum	Average
Barium-lanthanum-140	Upstream	5	<2	—	—	<0.007	—
	Downstream	50	<2	—	—	<.007	—
Cesium-137	Upstream	3	<.5	—	—	<.003	—
	Downstream	45	2.0	<0.5	<0.5	.010	<0.003
Tritium	Upstream	6	500	340	436	.017	.014
	Downstream	124	36,700	500	9,180	1.2	.31
Iodine-131	Upstream	—	—	—	—	—	—
	Downstream	109	<3	—	—	<1	—
Strontium-89	Upstream	5	<2	—	—	<.07	—
	Downstream	50	<2	—	—	<.07	—
Strontium-90	Upstream	5	2.3	.66	1.4	.8	.5
	Downstream	50	2.5	.60	1.6	.8	.5
Technetium-99	Upstream	3	<.5	—	—	<.0002	—
	Downstream	45	.84	.5	<.5	.0003	<.0002

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).
[b] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

Table 8. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, January-June 1971

Location	Concentration (pCi/liter)			
	Alpha radio-activity	Uranium	Beta radio-activity	Tritium
Des Plaines River[a] (above Sawmill Creek)	1.9	1.8	12	506
Des Plaines River[b] (below Sawmill Creek)	2.0	1.9	13	542

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.

residue. Separate samples were analyzed specifically for tritium. Although small amounts are produced by cosmic-ray interactions with the atmosphere, the bulk of the tritium in above-site water originated in nuclear detonations. Traces of cesium-137, strontium-90, and technetium-99 were also added by wastewater on some days, although these nuclides were also present in fallout. The total concentration, however, regardless of source, must be used in assessing the health hazard of a radionuclide not naturally present in the environment. The

Table 9. Radioactivity in Des Plaines River water, Argonne National Laboratory, January-June 1971

Radionuclide	Location[a]	Number of samples	Concentration[b] (pCi liter)		
			Maximum	Minimum	Average
Barium-lanthanum-140	Upstream	3	<2	–	–
	Downstream	5	<2	–	–
Cesium-137	Upstream	–	–	–	–
	Downstream	2	<.5	–	–
Tritium	Upstream	3	583	390	506
	Downstream	10	1,560	250	542
Plutonium (alpha)	Upstream	3	<.5	—	—
	Downstream	5	<.5	—	—
Strontium-89	Upstream	3	<2	—	—
	Downstream	5	<2	—	—
Strontium-90	Upstream	3	2.5	1.6	2.0
	Downstream	5	2.2	1.3	1.7
Technetium-99	Upstream	—	—	—	—
	Downstream	2	<.5	—	—
Thorium (alpha)	Upstream	3	<.05	—	—
	Downstream	5	<.05	—	—
Uranium (alpha)	Upstream	2	1.8	1.8	1.8
	Downstream	5	2.5	1.6	1.9

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).
[b] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

percent of the AEC standard given in the table was calculated on this basis. As indicated in the table, the beta radioactivity in the creek was very low compared to the AEC standards.

Since Sawmill Creek empties into the Des Plaines River, the radioactivity in the latter stream is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above the mouth of Sawmill Creek and twice a month below the mouth to determine if the radioactivity in the creek has any effect on the radioactivity in the river. The total radioactivity is summarized in table 8, and the results of analysis for specific elements and radionuclides are given in table 9. Tritium was the only nuclide whose concentration was higher below the mouth of Sawmill Creek, and the additional activity at this location evidently originated in Argonne wastewater. However, the average and maximum concentrations below the creek amounted to only 0.02 and 0.05 percent, respectively, of the AEC standards. The concentration of tritium in the river above the creek is similar to that found last year in the Des Plaines River and to that found in other streams in the area. Below the mouth of the creek, the concentration decreased slightly from the 1970 average.

The concentrations of the other radionuclides and the total alpha and beta radioactivities were in their normal ranges at both locations. Thus, except for tritium, no evidence of radioactivity from Argonne was found in the river. The annual average beta radioactivity was about the same as in 1970. The natural nonvolatile beta radioactivity in the river is 5 pCi/liter, and the excess (about 7 pCi/liter) was due to fallout.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium-89, iodine-131, and barium-140 were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 3 pCi/liter for the other two radionuclides. The strontium-90 and cesium-137 concentrations are given in table 10. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The strontium-90 and cesium-137 concentrations during the first half of 1971 were nearly unchanged from the corresponding period of 1970.

Table 10. Fission product concentration in milk, January-June 1971

Date collected (1971)	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
January 6	<10	6.5
February 3	<10	7.1
March 3	17	5.8
April 7	16	5.8
May 5	40	4.9
June 2	26	4.8
Average	18	5.8

Conclusion

Argonne's contribution to the environmental radioactivity was primarily limited to tritium, argon-41, cobalt-60, and barium-140 in the air on the site and to tritium in water from Sawmill Creek and the Des Plaines River. The only radioactivity detected off the site was the tritium in the two streams. The concentrations were low and did not constitute a health hazard. Fallout from nuclear detonations continued to be the principal source of nonnatural radioactivity in the environment. Fallout radioactivity was about 40 percent greater than the corresponding period in 1970.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1970	January 1972

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2. Brookhaven National Laboratory[3]
July–December 1967

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by radioactivity in the cooling air from the research reactors,

---

[3] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the Second Half of 1967," Associated Universities, Inc., Upton, N.Y.

(2) by radiation from an ecology forest gamma-ray source, and (3) by low-level radioactive liquid wastes released to a stream that forms one of the headwaters of the Peconic River (figure 3). The radiation levels resulting from reactor air effluent and the ecology forest source are monitored continuously by four stations located at the site boundary. The liquid waste effluent from the Laboratory sewage processing plant is monitored continuously at the point where the stream leaves the site.

Area monitoring

The average weekly radiation levels at the Brookhaven National Laboratory site perimeter (figure 4), due to laboratory operations, are given in table 11. Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to a cesium-137 source located in the nearby forest. However, the radiation levels at this location are within the established AEC radiation protection standard which is 500 mrem/a for individuals in the general population. Values of radiation background levels undisturbed by laboratory operations also have been included in table 11 for purposes of comparison.

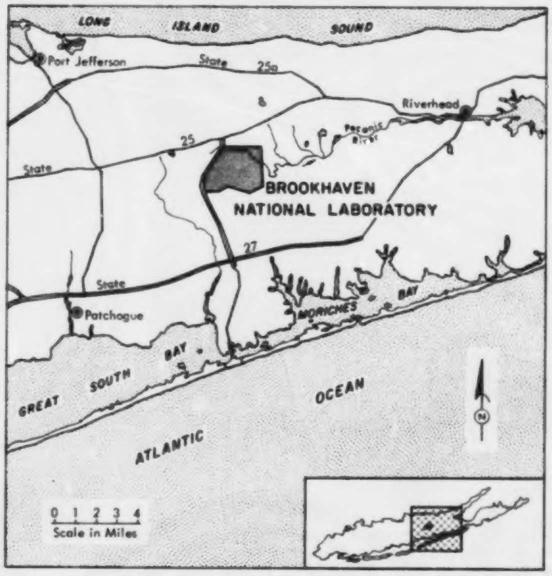
LONG ISLAND SOUND
Port Jefferson
State 25a
8
Riverhead
Peconic River
25
State
BROOKHAVEN NATIONAL LABORATORY
27
State
Patchogue
MORICHES BAY
GREAT SOUTH BAY
OCEAN
ATLANTIC
N
0 1 2 3 4
Scale in Miles

Figure 3. Brookhaven National Laboratory and surrounding area

Table 11. External gamma radioactivity at BNL site perimeter due to laboratory operations,[a] July-December 1967

1967	Average exposure rates (mR/week)			
	North-west perimeter	South west perimeter	South-east perimeter	North-east perimeter
July	0.30	0.49	0.15	2.50
August	.15	.08	.08	2.41
September	.14	.25	.13	2.05
October	.35	.00	.12	1.86
November	.02	.14	.31	1.42
December	.18	.35	.32	1.36
Maximum weekly reading (July-December)	0.91	1.91	0.93	2.94
Average undisturbed background (July-December)	1.91	1.90	1.76	1.78
1967 summary				
January-June	0.15	0.16	0.28	2.02
July-December	.19	.21	.18	1.93
January-December	.17	.19	.23	1.98
Maximum weekly reading	.91	1.91	1.06	4.46
Average undisturbed background (January-December)	1.87	1.83	1.76	1.80

[a] Due principally to argon-41 in reactor cooling air and at the northeast perimeter, to the ecology forest cesium-137 source.

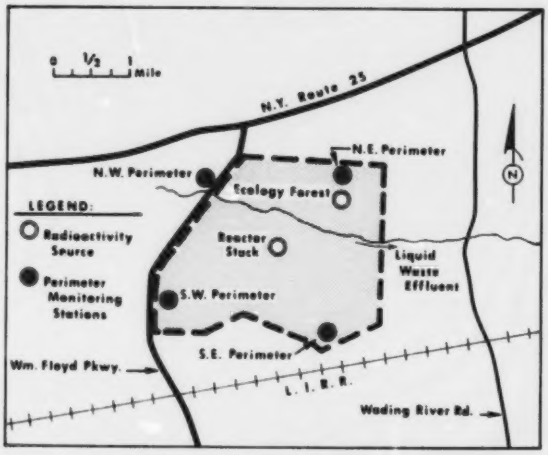
0 1/2 1 Mile
N.Y. Route 25
N.E. Perimeter
N.W. Perimeter
Ecology Forest
LEGEND:
○ Radioactivity Source
● Perimeter Monitoring Stations
Reactor Stack
Liquid Waste Effluent
S.W. Perimeter
S.E. Perimeter
Wm. Floyd Pkwy.
L. I. R. R.
Wading River Rd.
N

Figure 4. Brookhaven National Laboratory monitoring station locations

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the BNL site. The average concentration and total amounts of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 12 for July-December 1967.

Analysis of composite samples of the effluent has shown that, on the average, no more than

140

Table 12. Gross beta radioactivity in liquid waste effluent at BNL site boundary, July-December 1967

1967	Average beta radioactivity concentration (pCi/liter)	Total beta radioactivity concentration discharged (mCi)	Tritium concentration (nCi/liter)	Tritium radioactivity (Ci)
July	24	3.3	3	0.4
August	24	2.2	4	.3
September	15	1.1	3	.2
October	22	2.1	7	.6
November	16	1.2	8	.6
December	39	3.6	54	4.9
January-June	68	33.4	8	3.7
July-December	24	13.5	13	7.1
January-December	45	46.9	10	10.8

20 percent of the radioactivity consists of strontium-90 and that no appreciable amounts of radioactive iodine or bone-seeking radionuclides, such as radium, are present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 1 nCi/liter.

The gross beta measurements do not include very low energy beta emitters, such as tritium, for which special analysis methods must be employed. The concentration and amount of tritium found during this reporting period in the laboratory's liquid waste effluent are also shown in table 12. The applicable AEC standard is 3 μCi/liter, averaged over a period of 1 year.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	December 1967

Reported Nuclear Detonations, April 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced on April 3, 1972, that fallout from the March 18 Chinese nuclear test temporarily resulted in a slight increase in radiation above normal levels over most of the United States.

Although the levels of radioactivity detected were higher than normal environmental levels, radiation doses to the general population from the highest levels found was estimated to be a small fraction of the annual amount received from natural background radiation.

The fallout apparently reached a peak concentration during the last 10 days of March and at most locations it had already decayed to levels which could not be detected by the sampling network.

The U.S. Atomic Energy Commission announced only one nuclear detonation for April 1972. An underground nuclear test with a yield of less than 20 kilotons was conducted Wednesday, April 19, 1972 at the Nevada Test Site by the U.S. Atomic Energy Commission.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

☆U.S. GOVERNMENT PRINTING OFFICE: 1972—484-497/5

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

CONCENTRATION FACTORS IN THE AQUATIC ENVIRONMENT

S. M. Jinks and M. Eisenbud. Radiation Data and Reports, Vol. *13*, May 1972, pp. 243–247.

Concentration factors for various freshwater and marine organisms as gathered from the literature are presented. Attention is called to the existence of considerable variability in the reported values, and the reasons for this variability are briefly discussed. In addition to the difference in concentration factors for the marine and freshwater environments and because of differences in concentrations of stable elements in the two systems other sources of variability include errors in sampling and analysis, physiological factors, and ecological disequilibria.

KEYWORDS: Concentration factors, crustacea, fish, fresh water, marine organisms, molluscs, plants, radionuclides, sea water.

RADIATION DATA AND REPORTS

Volume 13, Number 6, June 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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DATA AND REPORTS

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

Radiological Surveys of Pearl Harbor, Hawaii, and Environs, 1966–1968

Daniel F. Cahill, H. D. Harvey, Jr., D. C. McCurry, W. D. Breakfield,

A. A. Moghissi, D. L. Norwood, N. E. Childs, and J. E. Regnier [1]

From April 1966 through June 1968, the Eastern Environmental Radiation Laboratory of the Environmental Protection Agency (formerly the Southeastern Radiological Health Laboratory, Bureau of Radiological Health, U.S. Public Health Service) conducted radiological surveys of a number of U.S. ports which service nuclear-powered submarines. These surveys were undertaken to determine whether nuclear submarine operations, which include berthing, repair, and servicing, had resulted in radioactivity levels in the harbor which could contribute a detectable radiation exposure to the public.

Six surveys were conducted at five ports with histories of extensive nuclear vessel activities, namely: (1) Thames River, New London, Conn.; (2) Hampton Roads, Va., including Portsmouth, Norfolk, and Newport News, Va.; (3) San Diego Harbor, Calif.; (4) Mare Island Naval Shipyard, Vallejo, Calif.; and (5) Pearl Harbor, Hawaii.

This report describes the conduct of the onsite surveys performed at Pearl Harbor in 1966 and 1968 and presents the results of the laboratory analyses of numerous environmental samples which lead to the conclusions that:

1. Small but detectable quantities of cobalt-60 were found exclusively in the sediment phases of the harbor.

2. Neither the harbor water nor any other environmental samples contained detectable cobalt-60 activity.

3. The total amount of cobalt-60 in the harbor sediment is small compared to the natural radioactivity present in Pearl Harbor and decreased significantly from 1966 to 1968.

4. The levels of cobalt-60 activity in the harbor were well below levels that could contribute a detectable radiation exposure to the public and do not constitute a hazard to public health or the environment.

5. Investigation of the physical and chemical characteristics of cobalt-60 in marine sediments indicates that cobalt-60 and possibly other neutron-activated corrosion products are released in a form which is not biologically available to marine or other forms of life.

Pearl Harbor is the major port for American naval ships in the Pacific Ocean. Included among the United States Pacific Fleet units in Hawaii is the Pacific Fleet Submarine Force which in recent years has consisted of both conventional and nuclear-powered vessels. Due to the nature of nuclear reactors, operations related to naval nuclear-powered submarines constitute a potential source of radioactive discharges to the harbor environment.

In 1966, a radiological survey of Pearl Harbor was conducted which was designed to locate, identify, and quantify the extent of any radioactive contamination of the harbor and its populated environs and to evaluate the public health significance of nuclear waste disposal practices. The 1968 survey was conducted to ascertain what changes in the radiological status of the harbor and environs had occurred in the intervening years.

Both surveys were conducted in essentially the same manner. Initially, a general scan of the harbor was made with an underwater gamma scintillation detector probe at selected points to delineate the areas and relative magnitude of radionuclide deposition. Based on these results, the subsequent efforts were primarily devoted to onsite survey and sample collection in the areas of highest activity or population density. This report presents the results and conclusions of the comprehensive environmental studies conducted at Pearl Harbor in these two periods.

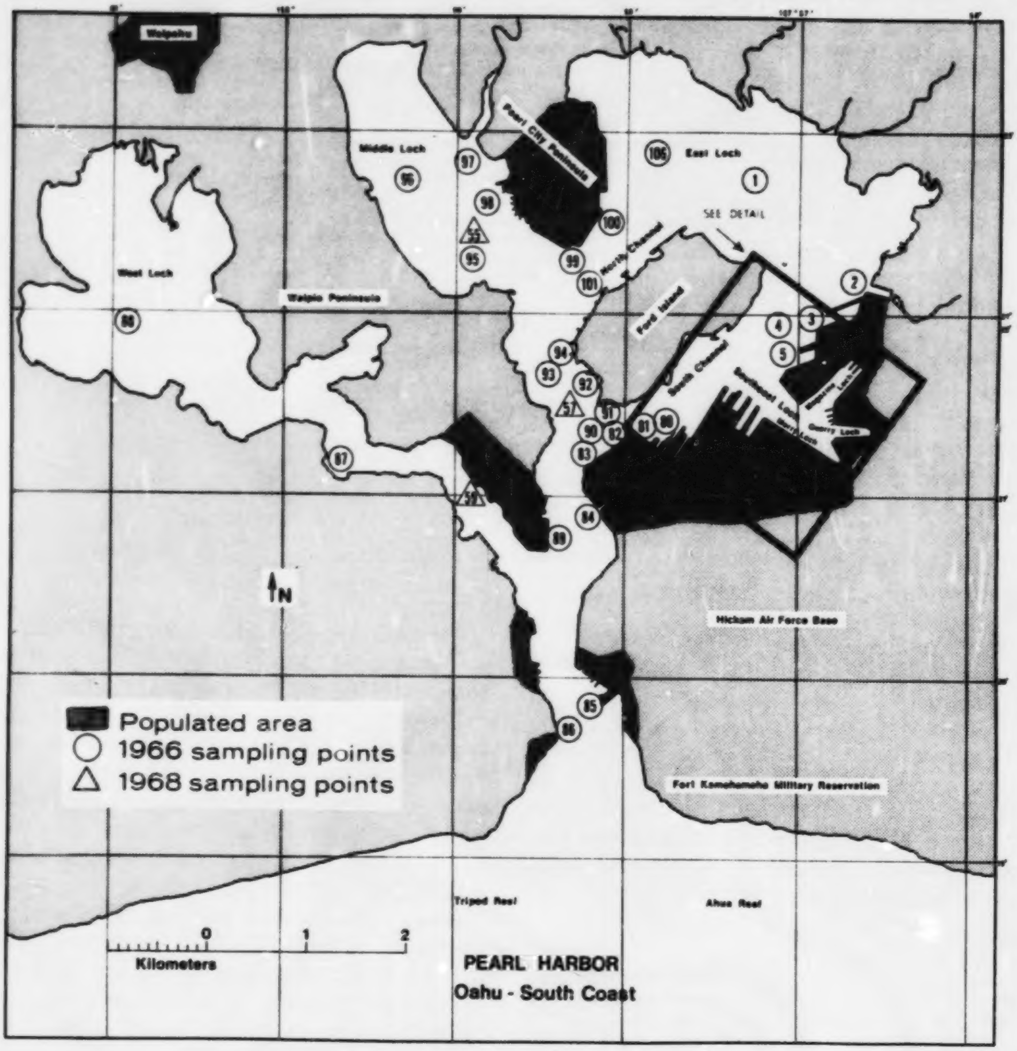
---

[1] Eastern Environmental Radiation Laboratory, Office of Research and Monitoring, EPA, Montgomery, Ala. Mr. Cahill and Dr. Regnier are presently located at the Twinbrook Research Laboratory, 12720 Twinbrook Parkway, Rockville, Md. 20852, and Dr. Moghissi is with the Western Environmental Research Laboratory, Las Vegas, Nev.

Characteristics of the harbor and vicinity

Pearl Harbor is located on the southern shore of the island of Oahu, 10 miles northwest of Honolulu. It is comprised of four major lochs: west, middle, east, and southeast (figure 1) with a total surface area of approximately 10 square miles (*1*). Southeast loch, subdivided into Magazine, Quarry, and Merry lochs (figure 2) contains the submarine base, berthing areas, and repair basins.

Fresh water from numerous streams and springs around the harbor perimeter provide inflows of 52.3 million gallons per day to west loch, 26.5 to middle loch, and 57.3 to east loch. There is no gauged flow into southeast loch (*1–2*). Other inflow consists of treated and un-


Waipahu
Middle Loch
Pearl City Peninsula
East Loch
SEE DETAIL
West Loch
Waipio Peninsula
North Channel
Ford Island
South Channel
Southeast Loch
Magazine Loch
Quarry Loch
Merry Loch
Hickam Air Force Base
Fort Kamehameha Military Reservation
Tripod Reef
Ahua Reef
N
1
2
3
4
5
80
81
82
83
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93
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100
101
106
55
57
59
0
1
2
Kilometers
PEARL HARBOR
Oahu - South Coast
Populated area
1966 sampling points
1968 sampling points

Figure 1. Pearl Harbor sampling locations for 1966 and 1968

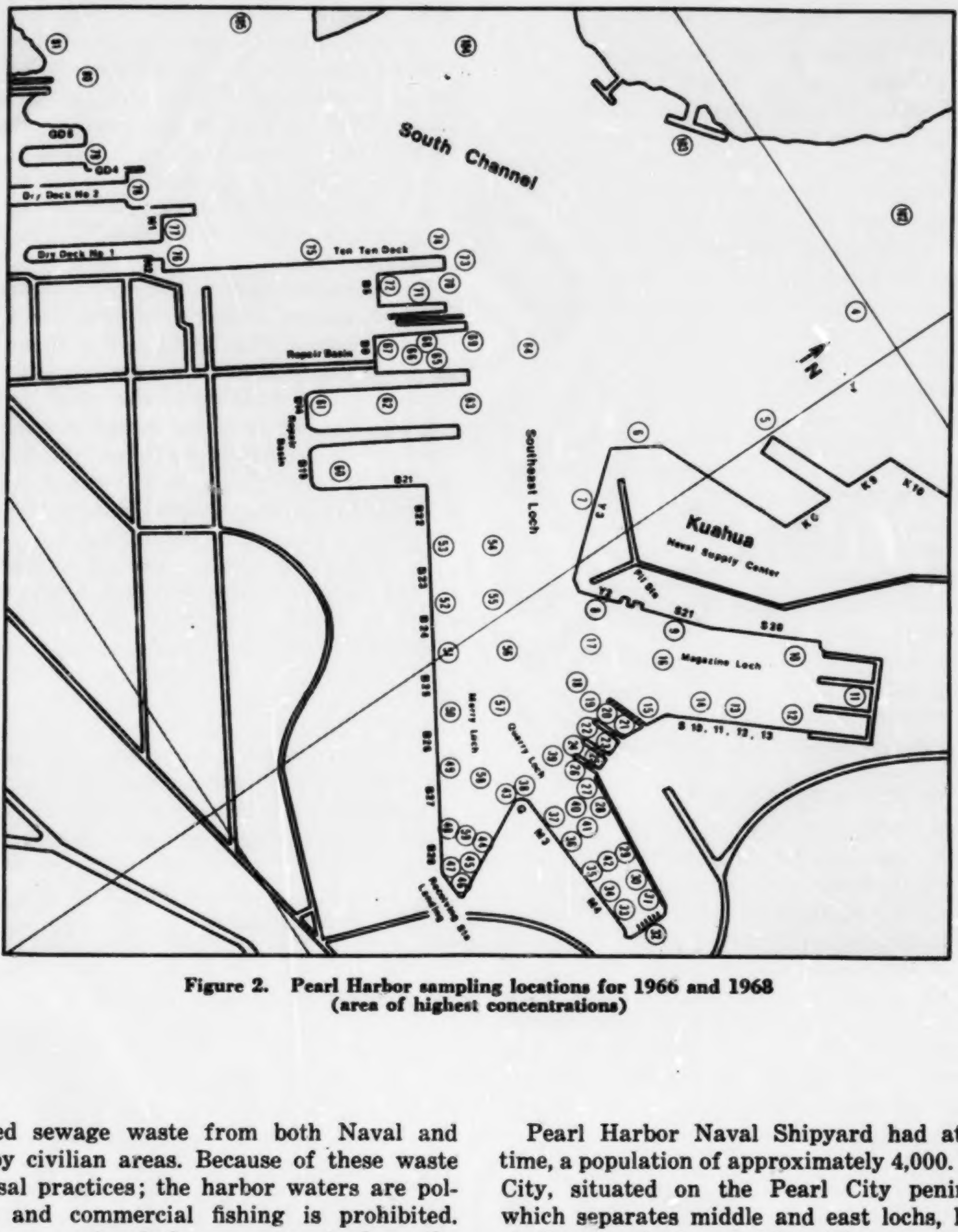
South Channel
GD6
GD4
Dry Dock No 2
Dry Dock No 1
Ten Ten Dock
Repair Basin
Southeast Loch
Kuahua
Naval Supply Center
Magazine Loch
Merry Loch
Quarry Loch
N
B21
B22
B23
B24
B25
B26
B27
B28
S21
S20
S 10, 11, 12, 13
K9
K10

Figure 2. Pearl Harbor sampling locations for 1966 and 1968 (area of highest concentrations)

treated sewage waste from both Naval and nearby civilian areas. Because of these waste disposal practices; the harbor waters are polluted and commercial fishing is prohibited. However, oyster beds are present along the harbor shoreline and small fish are caught for bait by salmon fishermen. The average rise and fall of the diurnal tides is approximately 2 feet which is not sufficient to produce noticeable currents within the harbor (*3*).

Pearl Harbor Naval Shipyard had at this time, a population of approximately 4,000. Pearl City, situated on the Pearl City peninsula, which separates middle and east lochs, had a civilian population of 8,200. The city of Waipahu, with a population of 7,600, borders on west loch (*4*). Portions of the areas bordering the harbor are used for sugar cane and watercress production, much of which is consumed locally.

Equipment

The field surveys were centered on the use of an underwater gamma scintillation detector system which provided useful onsite data for defining the harbor areas which contained detectable gamma radioactivity. The detection system consisted of an underwater probe connected by electrical cables to a multichannel gamma pulse height analyzer aboard the boat. The spectrometer was powered by a 60 cycle, 115 V a.c., portable gasoline generator. The probe was constructed of a 4- by 4-inch NaI (Tl) crystal and associated photomultiplier and preamplifier sealed within a watertight 7-inch diameter, 0.5-inch thick lucite tube. A fitted styrofoam jacket provided shock and thermal protection for the crystal. This type of probe construction permitted detection of gamma emissions from the harbor water and sediment with a minimum of photon energy degradation.

A modified Landing Craft Mechanized (LCM) with a bow davit for raising and lowering the underwater probe was used for transportation. The flat bottom of the craft provided a stable platform for the electronic equipment and access to shallow areas.

Sample collection and analyses

Gamma detector probe readings were obtained by lowering the probe to the harbor bottom and counting for 10 minutes. A gamma spectrum taken from an area of the harbor which had a low level (background) of gamma radioactivity was automatically subtracted. Since no gamma-emitting radionuclides other than cobalt-60 and potassium-40 were detectable in the field, the relative activities of different areas of the harbor were assessed as a function of the counts accumulated in the energy region corresponding to cobalt-60.

Using these data as a guide, bottom sediment and harbor water samples were collected for laboratory analysis from areas of high, intermediate, and low cobalt-60 activities. Bottom sediment collected with a Birge-Ekman dredge was dried at 105°C. in the laboratory, and ground to a fine powder. One-liter aliquots were counted for 50 minutes in a multichannel gamma pulse-height analyzer. Smaller aliquots of bottom sediment were also counted for gross alpha and beta radioactivity. Shore sand was similarly analyzed. Acidified harbor water samples and samples of well, stream, and tap water collected from populated areas surrounding the harbor were counted for 50 minutes in 3.5 liter geometry with the gamma pulse-height analyzer. The residue from evaporation of 1-liter aliquots was counted for gross alpha and beta activities.

Fish, oyster, and watercress samples collected from the harbor and environs by the State of Hawaii Fish and Game Division were preserved in alcohol and shipped to the Eastern Environmental Radiation Laboratory in Montgomery, Ala. Whole samples were gamma analyzed as described. In addition, the fish and oysters were divided into edible and inedible portions for further analysis and finally ashed for gross alpha and beta counting.

In 1968, Navy divers collected 18-inch-long core samples of bottom sediment from selected areas. A 24-inch plastic tube was pushed vertically into the silt until at least 18 inches had been contained. The top was capped, the tube withdrawn, and the bottom capped. On board ship, sweeping compound was added to the tube to retain the natural stratification of the sample. Seventeen of the samples collected were considered to be representative of the area surveyed. In the laboratory, these samples were frozen and cut into 1-inch-thick segments for gamma analysis to provide depth profiles of the radionuclide deposition.

Results

Cobalt-60 was present in the harbor in small quantities and could be attributed to nuclear submarine operations. Tripler Army Hospital, the only known isotope user in the vicinity, discharged its isotope waste via an outfall into the ocean, 5 miles southwest of the harbor entrance. Slight, but detectable cerium-144 activities of approximately 1 pCi/g dry weight of sediment were present in the samples collected in 1968. The absence of this nuclide in 1966 and its uniform distribution in low activities throughout the harbor in 1968 suggest that the cerium-144 probably resulted from fallout. Gross beta radioactivities of samples, when adjusted for potassium-40 and cobalt-60 contri-

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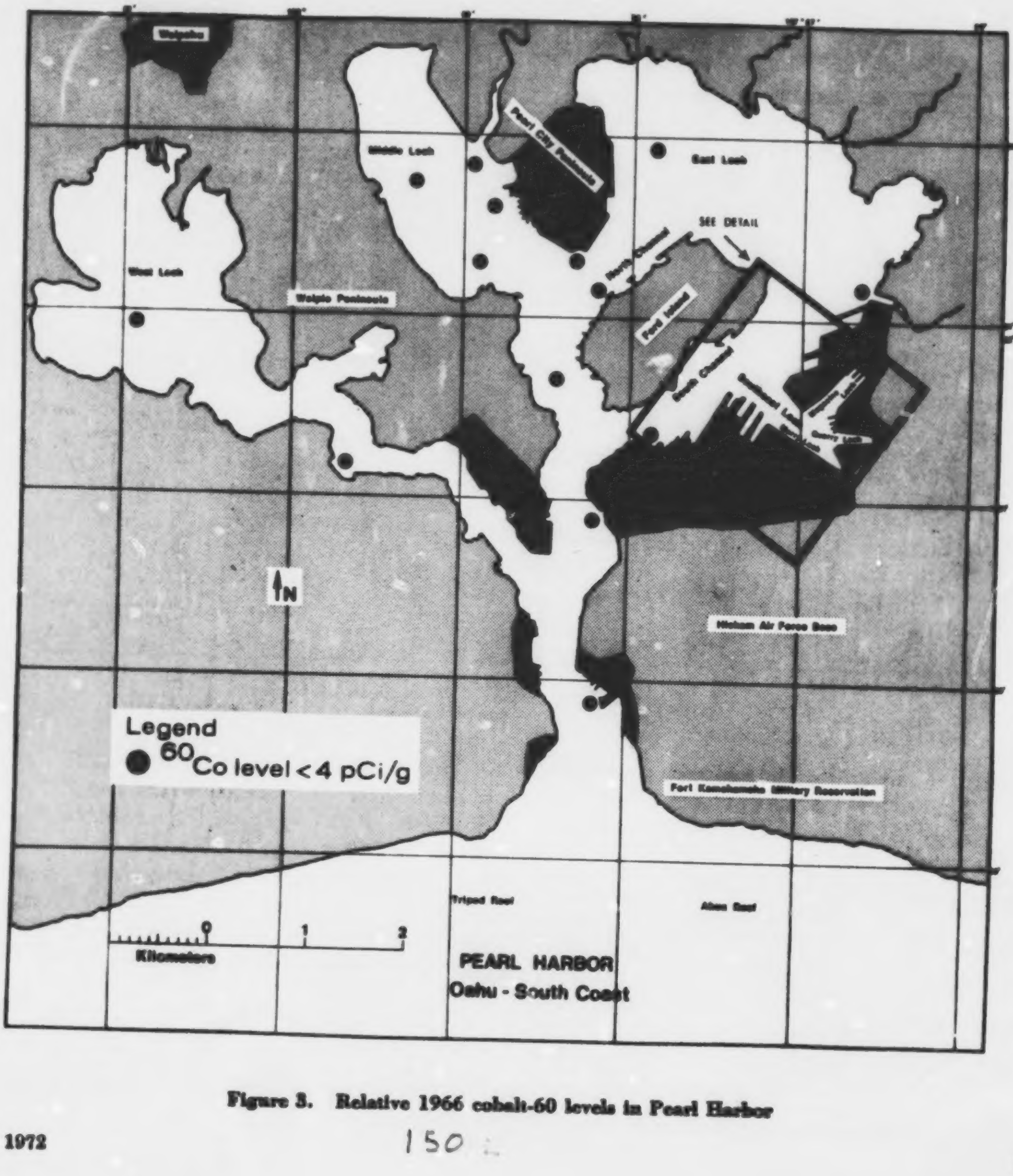
butions, were <1 pCi/g dry weight. Gross alpha radioactivity was also <1 pCi/g dry weight.

Cobalt-60 was found exclusively in the sediment phase of the harbor. Neither the harbor water nor any other environmental samples contained detectable cobalt-60 activity (table 1). The amount of radioactivity associated with sediments collected from different areas of the harbor corresponded directly to the areas of extensive nuclear vessel operations, i.e., the highest cobalt-60 levels were found in southeast loch, primarily at the berthing area of Quarry loch (figures 3–6). Areas of transient operations such as the main channel and the Naval Ammunition Depot in west loch contained little or no detectable cobalt-60 radioactivity.


Waipahu
Middle Loch
Pearl City Peninsula
East Loch
SEE DETAIL
West Loch
Waipio Peninsula
North Channel
Ford Island
South Channel
Southeast Loch
Magazine Loch
Quarry Loch
N
Hickam Air Force Base
Legend
● ^{60}Co level < 4 pCi/g
Fort Kamehameha Military Reservation
Tripod Reef
Ahua Reef
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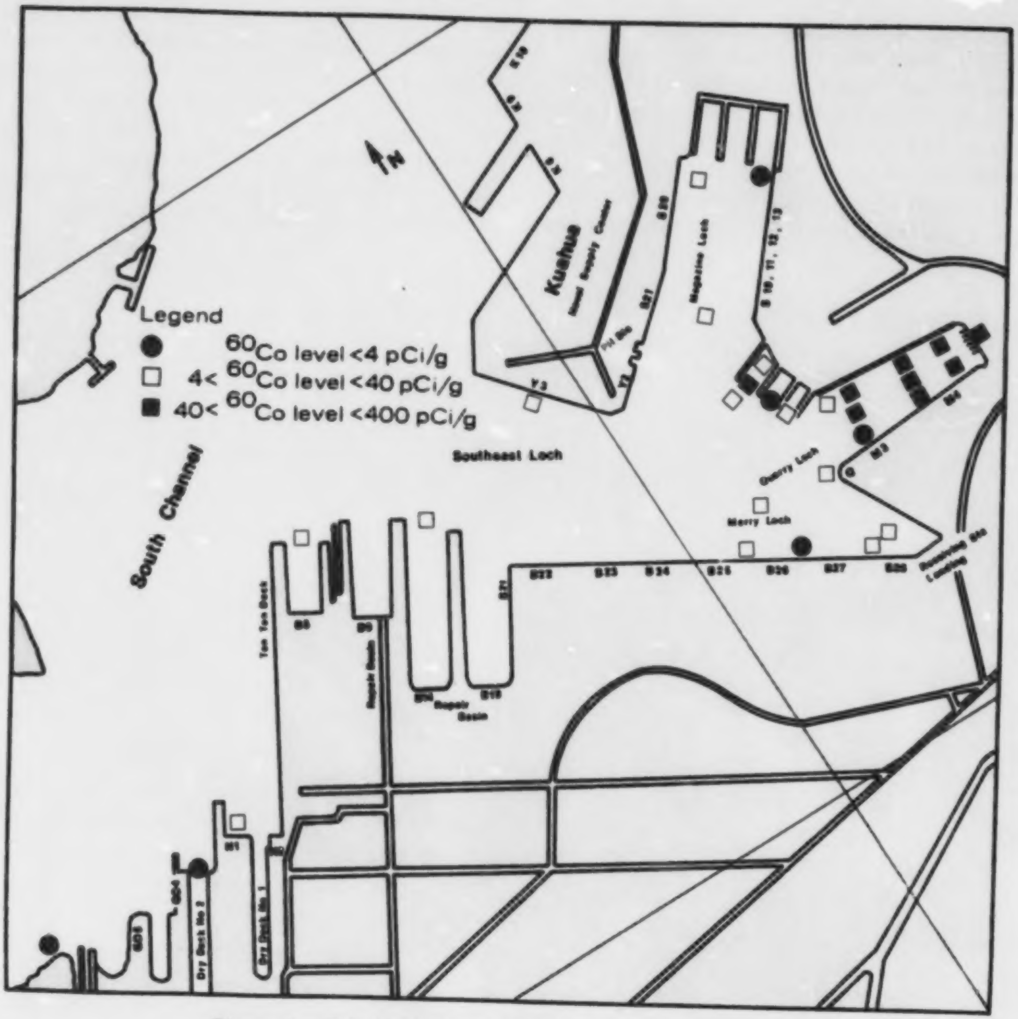
2
Kilometers
PEARL HARBOR
Oahu - South Coast

Figure 3. Relative 1966 cobalt-60 levels in Pearl Harbor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● ^{60}Co level <4 pCi/g
☐ 4< ^{60}Co level <40 pCi/g
■ 40< ^{60}Co level <400 pCi/g
N
Kuahua
Magazine Loch
Southeast Loch
Quarry Loch
Merry Loch
South Channel
Ten Ten Dock
Repair Basin
Dry Dock No 2
Dry Dock No 1
B22
B23
B24
B25
B26
B27
M3
M4

Figure 4. Relative 1966 cobalt-60 levels in Pearl Harbor (area of highest concentrations)

Table 1. Gamma analysis of environmental samples

Sample	Location	Gamma activity[a]
Tap water:	Pearl City fire station	ND
Well water:	Inland of middle loch	ND
Stream water:	Sumida farm, Pearl City	ND
Shore sand:	Pearl City peninsula	ND
Watercress:	Sumida farm, Pearl City	ND
Oysters:	West loch	ND
Fish:	West loch	ND
Harbor water:	Location 11	ND
	Location 21	ND
	Location 29	ND
	Location 32	ND
	Location 33	ND
	Location 68	ND
	Location 78	ND
	Location 81	ND

[a] Exclusive of potassium-40.

ND, nondetectable activity, i.e., <10 pCi/liter of water or 0.04 pCi/g of solids.

The results of the 1966 and 1968 surveys showed that this radioactivity has little tendency to disperse from the probable sites of initial injection into the harbor (figures 3 and 5). Sediment samples comparably collected from the same locations (table 2) showed a statistically significant decrease[2] in cobalt-60 level from 1966 to 1968 (figures 4, 6 and 7).

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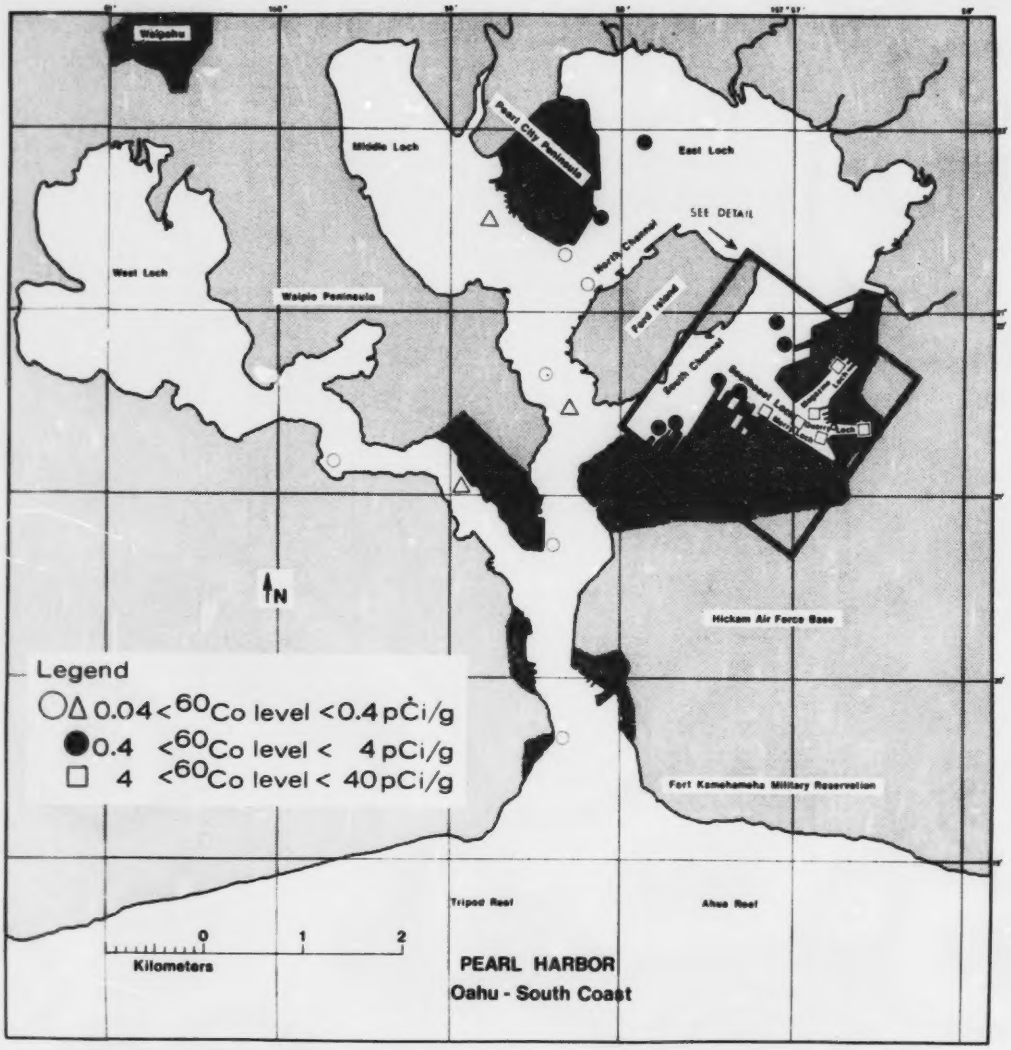
[2] Mann-Whitney U Test at 0.5 level of significance.


Waipahu
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East Loch
SEE DETAIL
West Loch
Waipio Peninsula
North Channel
Ford Island
South Channel
Southeast Loch
Magazine Loch
Merry Loch
Quarry Loch
N
Hickam Air Force Base
Legend
○△ 0.04 < ^{60}Co level < 0.4 pCi/g
● 0.4 < ^{60}Co level < 4 pCi/g
☐ 4 < ^{60}Co level < 40 pCi/g
Fort Kamehameha Military Reservation
Tripod Reef
Ahua Reef
0
1
2
Kilometers
PEARL HARBOR
Oahu - South Coast

Figure 5. Relative 1968 cobalt-60 levels in Pearl Harbor (triangles indicate 1968 sampling points only)

The highest sediment activity detected in 1966 was 105 pCi ^{60}Co/g versus 33 pCi ^{60}Co/g in 1968. The average cobalt-60 activity for samples collected in southeast loch was 33 pCi/g in 1966 and 11 pCi/g in 1968. However, core samples collected in 1968 (table 3) suggest that the apparent reduction in sediment cobalt-60 activity may have been in part an artifact of the dredge sampling technique rather than migration of the cobalt out of the harbor. The Birge-Ekman dredge collects approximately the top 4 inches of sediment whereas the core samples indicate that the majority of the cobalt-60 activity was at depths greater than 4 inches in 1968. Therefore, the implication is that the decreased cobalt-60 activity is probably due to radioactive decay of cobalt-60 and reduction of direct discharge of nuclear reactor waste into the harbor. In the absence of discharges to the harbor, the contaminated sediment surface of 1966 would have been covered to some extent by uncontami-

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Table 2. Cobalt-60 analysis of harbor sediment obtained by dredge sampling 1966 and 1968

Sampling number and location		Cobalt-60 activity[a] (pCi/g dry weight)	
		1966	1968
2	Entrance to Halawa stream CINC PAC landing	0.1	—
4	Midchannel off USS Arizona	—	2.2
5	50 yards off K-8	—	3.3
6	Tied at K-3	—	1.9
7	Tied at Y-3	13.2	8.8
10	Tied middle ARD-30	4.4	—
12	Tied at sign S-12, S-13	1.5	8.3
16	Midchannel Magazine Loch off S-21	14.3	9.4
17	Middle of entrance to Magazine Loch	—	5.9
18	100 yards off entrance to S-7, S-8	20.7	—
19	Middle of entrance to S-7, S-8	58.8	—
20	Center of S-7, S-8	—	8.4
21	Tied middle sub-base barge	84.2	—
22	Middle entrance to S-5, S-6	2.4	—
23	Middle of base of S-5, S-6	—	5.8
24	Middle entrance to S-3, S-4	9.6	—
25	Tied middle of base of S-3, S-4	—	4.9
27	Tied middle of S1C	14.2	—
28	Tied at sign S1B, S1C	73.4	29.3
29	Tied at sign S1A, S1B	78.6	30.7
30	Tied 1/4 way down from sign S1A	—	25.0
31	Tied at sign S1A	105.1	14.1
32	Tied middle small boat piers	104.7	13.9
33	Tied opposite sign S1A	56.8	16.1
34	Tied opposite location 30	—	11.5
35	Tied opposite sign S1A, S1B	50.8	17.5
37	Tied opposite middle S1C	2.1	16.1
38	Tied middle Merry Point pier	5.2	7.9
40	Midloch off middle of S1C	62.3	19.5
41	Midloch off sign S1B, S1C	—	20.0
42	Midloch off sign S1A, S1B	79.3	14.4
45	Tied at sign B27, B28	9.2	—
49	Tied at sign B26, B27	1.7	—
50	Tied at sign B25, B26	21.8	—
51	Tied at sign B24, B25	—	6.3
53	Tied at sign B22, B23	—	4.0
54	Midloch off sign B22, B23	—	7.8
55	Midloch off sign B23, B24	—	4.0
57	Midloch off sign B25, B26	11.2	—
59	Midloch off sign B27, B28	39.8	35.5
60	Tied at B30	—	3.6
62	Center of slip B12, B16	—	3.6
63	Middle of entrance to slip B12, B16	15.1	—
64	Midloch off slip B7, B11	—	4.8
66	Tied at B10	—	5.5
67	Tied middle B9	—	12.7
69	Tied middle B7	—	2.5
70	Middle of entrance to slip B4, B6	11.3	—
71	Tied middle B6	—	3.8
74	Tied at north end of Ten Ten dock	—	1.6
76	Tied at south end of Ten Ten dock	—	.8
77	Tied at midcaisson dry dock 1	24.6	2.6
78	Tied at midcaisson dry dock 2	2.4	8.2
79	Tied at midcaisson dry dock 3	—	.6
80	Tied at Dolphins off finger piers at GD5	—	.9
81	20 yards off landing C	1.0	—
84	Tied at midcaisson dry dock 4	.4	—
85	Tied Hickam Field wharf	.1	—
86	Tied Fort Weaver wharf	—	.1
87	Tied middle of W4 NAD	.1	.1
88	50 yards off fish pond	ND	—
89	Tied at W21	—	.1
93	Midchannel between markers 39 and 40	.9	.3
95	Tied at D1-N	.4	—
96	Tied at D8-N	.2	—
97	50 yards off entrance to Waiawa Stream	ND	—
98	20 yards off L pier	.1	—
99	Tied middle of pier at Peninsula Point	.9	.2
100	Shore line at V-4	—	.6
101	Tied middle of F-9	1.8	.2
102	Tied Mauka pier F-8	—	1.3
103	Tied at middle of F-5	—	1.8
105	Tied at tip of F-1	—	.7
106	Tied at X15-3	1.1	.6
55[b]	50 yards off finger piers, Pearl City Peninsula	—	.3
57[b]	Tied at channel marker	—	.1
59[b]	Midchannel off W-16	—	.3

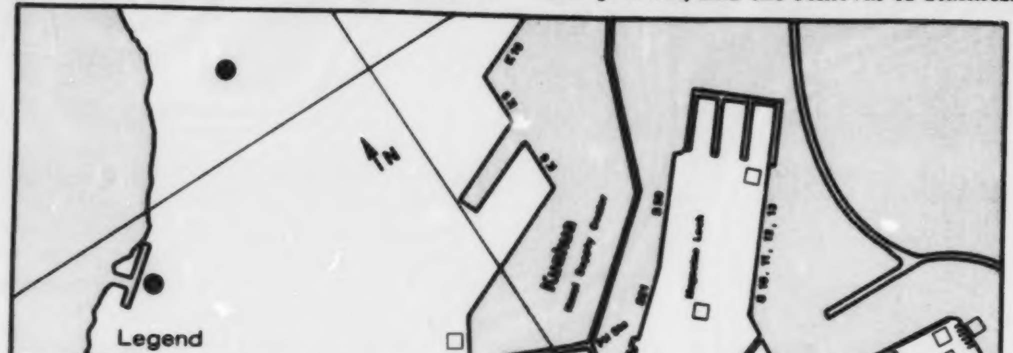
[a] Limit of detectability, 0.04 pCi/g dry weight.
[b] 1968 location number.
ND, nondetectable.

nated silt by 1968, thereby diluting the activity collected by the dredge samples.

Observation of the radionuclide deposition pattern within the harbor in 1966 and 1968 (figures 3 and 5) shows that the cobalt-60 has not undergone any noticeable migration or dispersion from southeast loch to previously uncontaminated areas.

Some significant characteristics of the cobalt-60 in the sediments

Because analysis of the field and laboratory data indicated a localization of the cobalt-60 activity in the sediment which correlated with deposition in the vicinity of the probable sites of isotope injection into the harbor, an investigation of the nature of cobalt-60 released from marine reactors was undertaken. The lack of dispersion of the cobalt-60 activity suggested the possibility that cobalt-60 was discharged in a physico-chemical form which facilitated rapid settling and binding in the sediment. Little information is available on the behavior of marine reactor effluent in the environment; however, cobalt-60 is a neutron-activated corrosion product, and the removal of stainless-steel


N
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● 0.04 < ^{60}Co level < 4 pCi/g
□ 4 < ^{60}Co level < 40 pCi/g
Southeast Loch
South Channel
Kuahua
Quarry Loch
Merry Loch
Ten Ten Dock
Repair Basin
Dry Dock No 2
Dry Dock No 1

Figure 6. Relative 1968 cobalt-60 levels in Pearl Harbor (area of highest concentration)

Table 3. Core sample analysis, concentration of cobalt-60 in relation to depth (pCi/g dry weight)

Depth below surface (inches)	Sample number																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1.5	4.4	4.7	1.2	25.9	2.0	0.6	2.5	1.5								
2	10.3	10.3	13.4	1.1	22.7	.9	.6	3.9								0.3	0.1
3	20.4	13.2	9.7	2.1	55.3	1.5	1.1	10.3									
4	13.2	7.9	8.6	1.5	55.8	2.4	10.4	8.0				0.2					.1
5	13.7	15.4	24.5	1.4	16.7	35.2	3.9	3.9									
6	6.4	18.8	8.0	3.9	44.0	17.1	2.6	1.4						0.5			
7	45.1	35.2	13.0	9.9	90.1	2.7	1.4	5.4									
8	9.9	12.0	13.7	13.8	52.2	23.7	1.6	18.6		7.8		.3	0.3				
9	9.1	11.2	11.8	14.4	22.4	1.2	3.5	7.8							0.3		
10	18.4	16.3	12.3	8.0	17.5	3.7	5.4	15.1									
11	27.1	21.1	40.1	28.0	32.3	12.7	13.8	2.5									
12	25.2	41.7	97.6	26.0	3.1	31.5	21.9	.4			3.8		.5		.2		
13	40.0	96.4	97.4	26.3	5.1	25.9	5.6	.2				.2					
14	57.2	38.3	.0	75.6	.9	55.5	1.0	.0									
15	65.4		.0	164.9	.6	27.4	.0	.2									
16			.0	248.0	2.1	131.5		.4				.2					
17			.3	66.2	16.4	28.0		.0									
18			.0	18.7		12.2		.7									
19			.0	28.4		.6		.4									
20			.1	.2		.0		.4									
21				.4		18.2		1.4									
22				109.4		24.1											

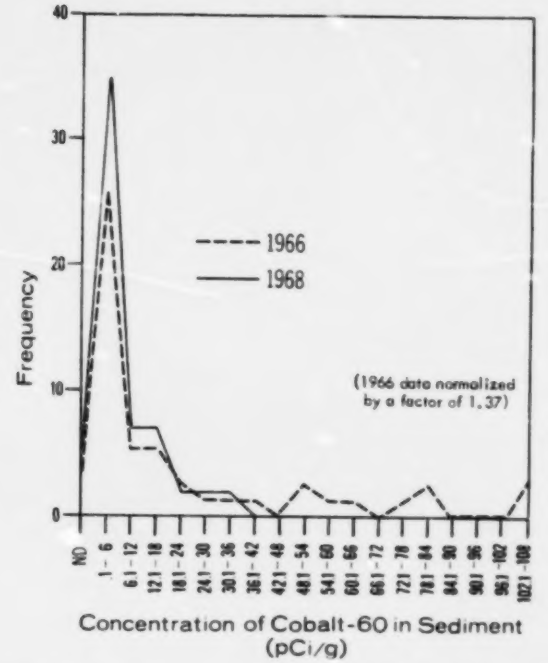

Figure 7. Frequency distribution of cobalt-60 data for 1966 and 1968

corrosion products by magnet from the ion exchange resin through which reactor primary coolant water passes prior to discharge has been reported (*5*). To investigate the chemical form of the nuclide, gamma pulse-height analysis of harbor sediment slurries was performed to determine their cobalt-60 activities. The solid and liquid phases were then separated by filtration and each phase scanned for its respective cobalt-60 activity. The filtrates contained no detectable cobalt-60 radioactivity.

The dried sediments were reconstituted to a slurry with demineralized water and stirred with a bar magnet. Metallic particles were readily separated by the magnet and found to contain cobalt-60 activity.

In order to determine how much of the resident activity in the sediment was present in association with these metallic particles, a container was constructed to hold a kilogram of dried sediment and sufficient demineralized water was added to produce a slurry. No further preparation of the silt was necessary. A revolving paddle wheel was used to keep the silt suspended. An electromagnet with a plastic cap was placed on the surface of the slurry to collect the magnetic particles. This geometry permitted the removal of the magnetic component of the slurry as free as possible of accompanying silt. Successive 15-minute separations throughout a 6-hour period were found to be the most efficient method of collection because the electromagnet's surface quickly became saturated with particles which hampered further extraction from the suspension.

The magnetic removal of cobalt-60 activity resulted in greater than 90 percent decontamination of several of the sediment samples. A typical result of these experiments is shown in the gamma spectra of figure 8. The spectra show a decrease in the initial cobalt-60 activity of the sediment with successive magnet extractions and, within counting error, the corresponding activity loss was accounted for in the isolated particles.

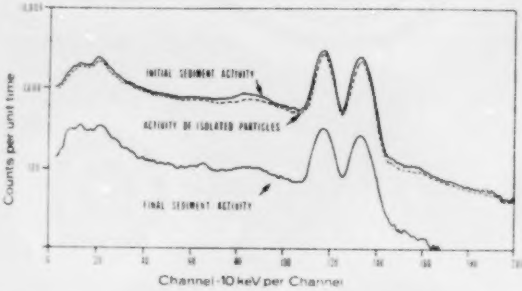

Figure 8. Results of magnetic extraction of cobalt-60 from harbor sediment

The collected particles were subjected to particle size analysis by passing a slurry of the particles through a U.S. Standard Sieve Series and Millipore filters. The results showed that approximately 90 percent of the cobalt-60 activity was associated with particles of 10–37 μm diameter. Attempts to remove the activity from the particles with dilute and concentrated reagents were unsuccessful, indicating that the cobalt-60 was an integral part of the particles.

Qualitative chemical analyses of aliquots of the isolated particles were performed by partial dissolution in aqua regia and subjecting the residue to an alkaline carbonate fusion. The solutions were combined and silicon oxide removed by repeated evaporation with concentrated HF. Paper chromatographic separations were performed with a solvent containing acetone, concentrated HCl and water (8:1:1 by volume) using Whatman No. 3 paper (*6*). Nickel, iron, and chromium could be readily identified. Cobalt apparently was present only in trace amounts. Trace concentrations of manganese were also inferred from the results of gamma coincidence-anticoincidence analysis of the particles which showed the presence of a 0.84 MeV peak, possibly manganese-54. Quantitative analyses were also performed on these solutions using the ion exchange separation procedure of Hague, et al. (*7*) and conventional precipitation techniques. The composition proved to be an iron alloy containing variable amounts of nickel and chromium.

Thus, it was demonstrated that the cobalt-60 activity found in the sediment of this harbor exists for the most part and possibly entirely in association with metal particles. The qualitative and quantitative analyses and the coincidence- anticoincidence counting of the particles suggest a stainless-steel composition. The size distrbution of the radioactive particles supports the idea that the cobalt-60 resulted from reactor corrosion products too small to be retained in the system and the resin bed and which had been discharged into the harbor with the water from reactor coolant expansion volume.

Preliminary studies were conducted to ascertain the magnitude of any assimilation of this metallic particulate form of cobalt-60 by bottom-feeding marine organisms. Two approaches were attempted: the first involved the maintenance of several varieties of bottom-feeding organisms in an environment containing fresh radioactive harbor sediment, and the second utilized isolated radioactive particles as an additive to fish food.

In a laboratory study, a circulating sea water aquarium was used to hold 2 liters of a slurry of Pearl Harbor sediment with a cobalt-60 activity of 48,800 pCi/liter or a total activity of approximately 0.1 μCi. Clams, oysters, shrimp, and mullet were introduced into this environment after their background gamma activity had been determined by pulse-height analysis. This experiment was carried out for 2 months. The organisms were counted every second day for the first 2 weeks, and once each week for the remainder of the experiment. The counting procedure for clams and oysters entailed a thorough rinsing with distilled water to remove silt from the shells and counting for 30 minutes on a 200-channel gamma pulse-height analyzer. The fish and shrimp were first anesthetized in a solution of 75 and 300 ppm, respectively, of tricainemethanesulphonate, then placed in a tubular holder with an aeration outlet, and counted for 30 minutes.

In the second experiment, two seawater aquaria were divided into eight compartments and two mullet housed in each. The mullet were counted individually for background activity as previously described. The fish were then fed a blended diet composed of equal parts of baby beef liver, spinach, and pablum to which had been added cleansed particles, magnetically isolated from harbor sediment, containing cobalt-60 activity. The activity of the food thus prepared was determined to be 45 pCi/g by counting six 10-g aliquots. Each compartment was allowed 2 g/day for 6 days each week. The absence of feeding on the 7th day encouraged the fish to consume any residue remaining from previous feedings. The experiment was conducted for 21 days with 18 feedings, and counting was performed twice each week.

The organisms existing in the contaminated sediment environment (total cobalt-60 activity of 0.1 μCi) exhibited no activity levels above the limit of detection of cobalt-60 which was 50 pCi under these conditions of counting geometry.

The fish which had been fed the cobalt-60 diet also showed no assimilation of a detectable body burden. However, because of the relatively low levels of activity utilized, amounting to a possible total intake of 810 pCi per fish, assuming each fish received the same amount of food, it can only be said that rapid and large scale uptake was not evident. A small level of assimilation could have occurred, but if so, it was below the limit of detection of cobalt-60.

Conclusions

In view of these results which indicate that cobalt-60 from marine reactors is not concentrated in representative types of marine biota, this cobalt-60 does not appear to be an internal radiation hazard. Furthermore, calculations based on the assumption of a plane isotropic cobalt-60 source of infinite extent in the sediment reveal that the external radiation dose at the air-surface interface is too small to be calculable.

The radiological surveys of Pearl Harbor indicate that the total amount of cobalt-60 in the harbor sediment is small compared to the natural radioactivity and has decreased from 1966 to 1968. The levels of cobalt-60 activity are below levels that could contribute a detectable radiation exposure to the public and do not constitute a hazard to public health or the environment. Further, the chemical form of cobalt-60 released from marine reactors, and possibly reactors in general, is in the form of metallic corrosion product particles which do not appear to be assimilated or transmitted in the food chain.

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Radiofrequency and Microwave Radiation Levels Resulting From Manmade Sources in the Washington, D.C. Area[1]

Stephen W. Smith and David G. Brown[2]

In order to determine the typical levels of radiofrequency and microwave radiation that result from manmade sources in an urban environment, measurements were made of peak power densities in the Washington, D.C. area during the summer of 1969. The highest levels measured (approximately 10^{-2} mW/cm^2) originated primarily from AM broadcast towers and airport radar installations.

During the past 25 years, the energy radiated in the microwave and radiofrequency (RF) regions for public, military, and commercial purposes has increased by several orders of magnitude. The biological effects of such nonionizing radiation became of concern to the U.S. Public Health Service and resulted in the enactment of Public Law 90–602, the Radiation Control for Health and Safety Act of 1968 (*1*). Test programs have been conducted to measure power densities from consumer devices emitting nonionizing radiation (*2*), and many investigators have examined possible harmful effects to life systems exposed to RF and microwave radiation (*3,4*). This work has included attempts to establish a basis for formulating radiation emission standards for selected products and frequencies.

There are presently no Federal, State, or private standards that apply directly to the situation of public exposure to RF or microwave radiation from high-powered electronic equipment such as broadcast towers or radar installations. There are, however, numerous standards in the United States and abroad that are designed to protect microwave oven users from exposure to excessive leakage radiation (*5*) and that recommend limits on radiation exposure to personnel working in RF or microwave fields (*6*). For example, the American National Standards Institute has recommended that occupational exposure for frequencies from 10 MHz to 100 GHz not exceed 10 mW/cm^2 as averaged over any possible 0.1 hour period and that in no circumstance should exposure exceed 1 mW–h/cm^2 (*7*).

In the past, the military and other organizations have studied the possibly hazardous radiation levels produced by individual radar facilities and high-powered, long-range broadcasting systems.[3] Recently, the Bureau of Radiological Health, Public Health Service (PHS), has made field measurements of RF levels near FM and TV broadcast towers in the Las Vegas, Nev., area (*8*). Extensive studies have also been made of ordnance hazards and the electromagnetic compatibility of RF sources. The Electromagnetic Compatibility Analysis Center (ECAC) of Annapolis, Md., maintains a large data base of characteristics and locations of RF emitters in the United States (*9*).

All of the above-mentioned investigations of possible hazards have been made in the immediate locale of individual emitters. No previous attempts have been made in the United States to measure the overall population exposure in an urban environment that results from the myriad broadcast towers, communications links, radar installations, and other sources of RF and microwave radiation typical of a large city.

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[1] Adapted from U.S. DHEW Publication No. (FDA) 72–3015, BRH/DEP 72–5, "Radio-frequency and Microwave Radiation Levels Resulting from Manmade Sources in the Washington, D.C. Area." Data obtained by White Electromagnetics, Inc., under PHS Contract CPE–R–22.

[2] Mr. Smith is with the Product Testing and Evaluation Branch, Division of Electronic Products, Bureau of Radiological Health, FDA, Rockville, Md. 20852, and Mr. Brown's present address is the University of Delat, Delat, Vietnam.

[3] ARK ELECTRONICS CORPORATION. Final technical report on research project to study radiation hazards caused by high power high frequency fields, U.S. Information Agency Contract #1A–11651. Ark Electronics Corporation, Willow Grove, Pa. 19090 (June 1, 1968).

Some crude models exist for calculating such an exposure, but work is just beginning in this area. Several measurements have been made of total manmade electromagnetic noise in a large city[4] (*10*), but these omit all contributions from narrowband sources. This report, then, represents an attempt to examine ambient RF and microwave radiation levels in an urban environment.

Experimental procedures

The city of Washington, D.C. may be unusual from the viewpoint of background RF radiation. Besides the normal proliferation of public and commercial emitters, Washington is a center for a host of government and military communication sources.

A summary listing was obtained from ECAC of Annapolis, Md., of all emitters with an average output above 10 watts reported to be located within a 50-mile radius of the Washington Monument. The data consisted of 1,430 communications sources and 99 radar sites. Types of emitters included AM and FM broadcast facilities, radar navigational aids, ship-to-shore communications, ground-to-air communications, teletype terminals, and police base communications.

Power output of transmitters listed by ECAC ranged from 0.1 kW to a 5,000 kW search radar installation. More than 200 of the listings had nominal outputs of 10 kW and above. It should be emphasized that these data included only un-

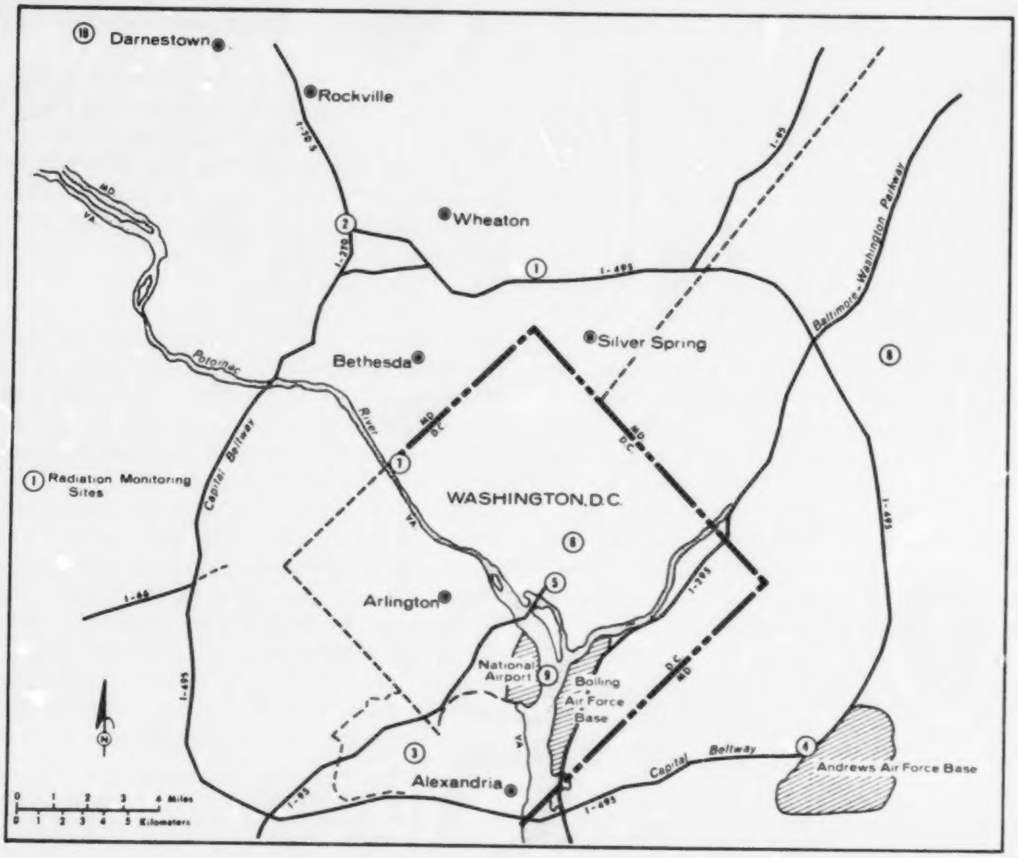
⑩ Darnestown
Rockville
I-270
I-70-S
Wheaton
②
①
I-495
I-95
Baltimore-Washington Parkway
Silver Spring
Bethesda
⑧
MD
VA
Potomac
River
MD
D.C.
MD
D.C.
Capital Beltway
① Radiation Monitoring Sites
⑦
WASHINGTON, D.C.
⑥
VA
I-66
⑤
Arlington
I-295
National Airport
⑨
Bolling Air Force Base
D.C.
MD
I-495
VA
③
Alexandria
Capital Beltway
④
Andrews Air Force Base
I-95
I-495
N
0 1 2 3 4 Miles
0 1 2 3 4 5 Kilometers

Figure 1. Map of Washington, D.C. showing monitored sites

classified sources. It was possible, then, to compare the experimental peaks with the parameters of individual emitters included in the listing and, in some instances, to predict the measured intensities.

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[4] NATIONAL BUREAU OF STANDARDS. Manmade radio noise measurements at the NBS Gaithersburg site and NBS Washington, PM-83-45, NBS Project 8340-40-83141. National Bureau of Standards. Gaithersburg, Md. (February 3, 1961).

Personnel of the division of Electronic Products and White Electromagnetics, Inc., monitored radiation from 20 Hz to 10 GHz at 10 locations distributed around the D.C. area. The locations were chosen with preference given to high-density population areas near high-powered electromagnetic energy sources. Table 1 lists the site, the date of monitoring, the hours of monitoring, and the number of sweeps through the spectrum. Figure 1 shows the location of the 10 monitoring sites. It should be noted that seven of the 10 sites were surveyed during normal working hours; i.e., 8:00 am to 5:00 pm. Two of the sites were surveyed during the evening as well as during normal working hours. Finally, one of the sites was tested for a total period of 24 continuous hours to obtain baseline data independent of time of day.

Table 1. Sites monitored for background radiation

Site	Date (1969)	Hours monitored	Spectrum scans
1. Holy Cross Hospital	July 18	1015–1415	10
2. Montgomery Mall Shopping Center	June 17	1300–1700	10
3. Cameron Station	July 24	1200–1600	12.5
4. Andrews AFB	July 25	1045–1545	7
5. Washington Mall	July 19	0700–1900	37
6. Brentwood Park	July 31	1250–1550	13
7. Sibley Memorial Hospital	August 7	1230–1630	13
8. Duval Senior High School	August 8	1100–1500	12
9. National Airport	August 12	1100–2300	30
10. Darnestown, Maryland	August 27–August 28	1030–1030	67

Data were acquired through the use of automatic equipment mounted in a van equipped with an independent 1 kW a.c. generator. The apparatus consisted of a White Electromagnetics, Inc., Automatic Spectrum Display and Signal Recognition System, Models 130A and 140A. These units scanned and plotted on chart recorders radiated intercepted signal amplitudes over the frequency range of 20 Hz to 10 GHz in 22 continuous bands. The equipment included a fully automated and integrated spectrum-scanning and plotting system controlled by a selectable, stored logic master which controlled the operations of input sensor, receiver selection, receiver band switching, and band output switching. The outputs included an X-Y plotter with data displayed on a calibrated multiband graph and an audio monitoring unit. A further description of the components and their specifications along with descriptions of the antennas is contained in reference (*11*). A block diagram of the instrumentation is shown in figure 2.

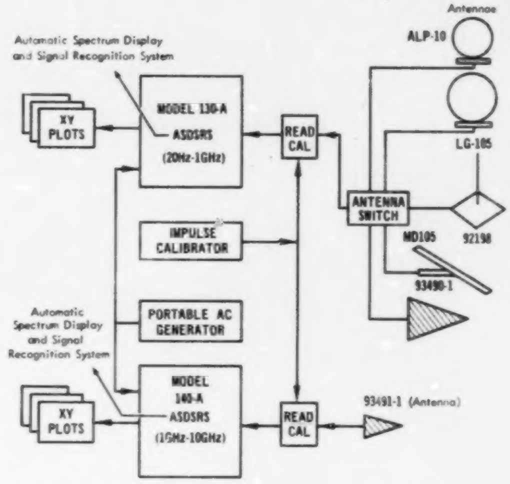

Figure 2. Mobile instrumentation van block diagram

During the monitoring, antenna azimuth location was referenced to magnetic north and measurements were made in each of the quadrants. The spectrum covered was scanned at a rate of roughly 1 minute per octave.

Peak and average measurements were taken at each site for frequencies from 20 Hz to 1 GHz (figure 3). The upper line on the chart was produced by the peak channel of the system (*11*) (this channel was driven by a peak-voltage-detecting device which had a rise time of 5 nanoseconds and was, therefore, capable of capturing very short duration events such as ignition noise and other forms of impulsive or broadband energy). In addition, this channel was sensitive to narrowband energy (i.e., signal sources of small bandwidth compared to that of the receivers) and responded to continuous-wave level (carriers) as the system scanned through its frequency range.

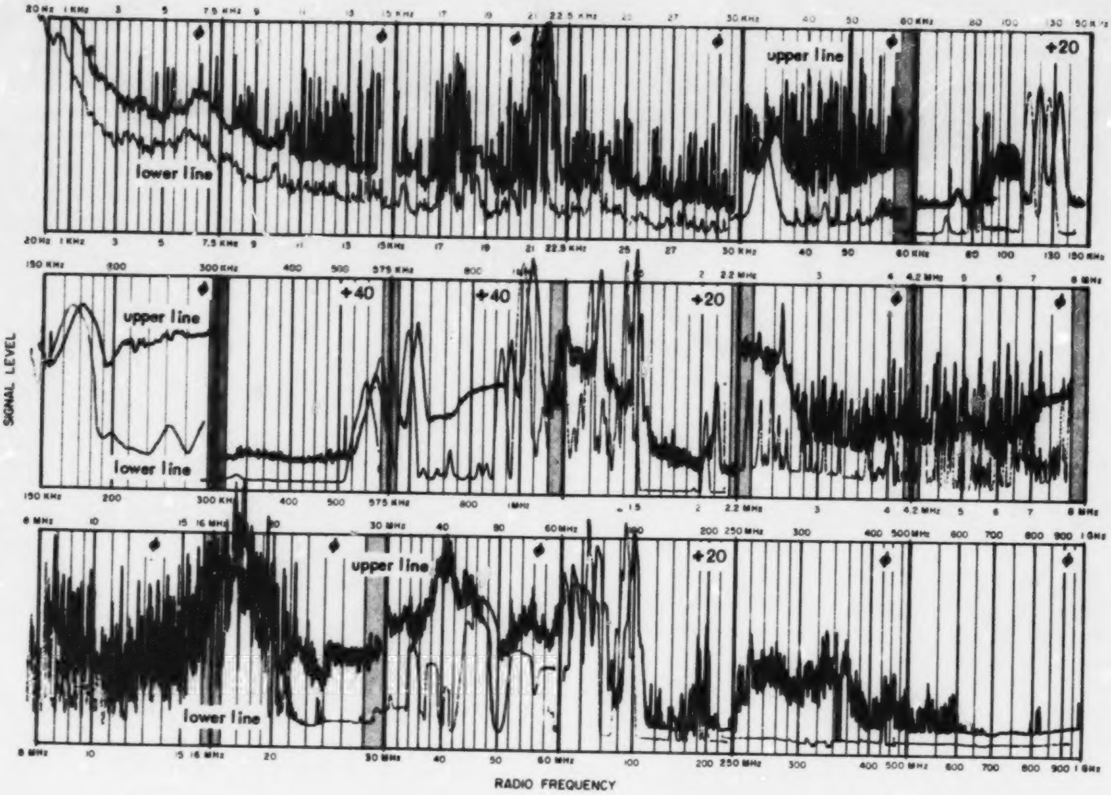

Figure 3. Radiofrequency spectrum chart for site 5 (Washington Mall)— 20 Hz to 1 GHz

The lower line on the same data sheet was produced by the average channel of the system (*13*). It was driven by an average-detecting device which responded to the root mean square (RMS) value of only the received narrowband signals. This channel, however, was not calibrated and was used to identify narrowband signals when compared to the peak channel. Thus, only the narrowband signals of the peak channel detector were considered in the analysis of the data.

For measurements ranging from 1.0 GHz to 10 GHz (figure 4) only the peak detector was used and operator discretion was necessary to determine whether the signals were broadband or narrowband. The raw data then consisted of peak-voltage values of received RF signal sources. Frequency overlap between bands was ignored.

Calibration curves were made at approximately half the sites. Each receiver was tested over its frequency range with a broadband pulse generator. The calibration traces were made in decibels relative to 1 microvolt for a broadband pulse. Conversion factors from broadband to narrowband calibrations were determined in decibels for each receiver's 3-dB bandwidth relative to a 1 MHz bandwidth. Antenna factors for each antenna were determined to convert the signals into terms of electric field strength in dB relative to 1 μV/m.

Data analysis

The raw background data for the 10 sites were in the form of 250 X-Y plots. To convert this information into digital form for computer analysis, each curve was traced by means

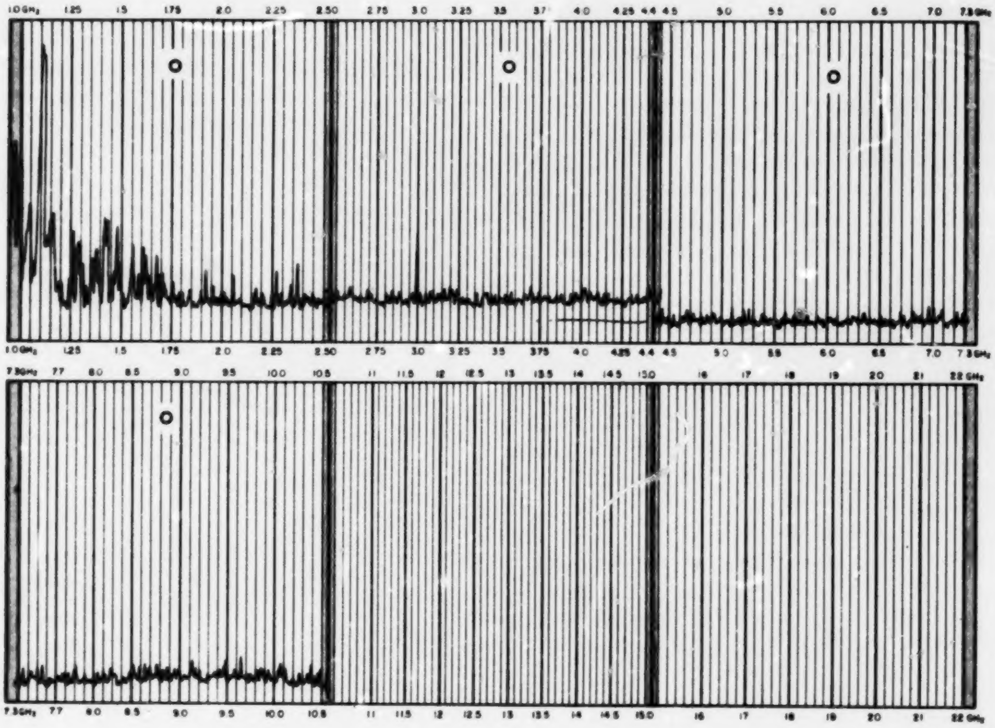

Figure 4. Radiofrequency spectrum chart for site 5 (Washington Mall)— 1.0 to 10 GHz

of a Gerber PF 10B Coordinates Digitizer, and each peak representing a narrowband signal was specified by three (x,y) coordinates. The data were then placed on coded punched cards. Four computer programs were written to arrive at power densities averaged over the number of spectrum scans for each survey site.

The first program grouped data from all the scans of one site into specific frequency bands corresponding to the frequency boxes on the typical chart. It then adjusted each data point to fall between 0 and 10,000. These operations were applied for each frequency "box." The second program dealt with the calibration traces for both intensity and frequency. The calibration data points were fitted to a fifth order polynomial.

The third program treated each frequency "box" individually. It first identified each narrowband peak for one chart. The peak voltages were then fitted to the calibration curves. Proper attenuation factors, cable loss values, and antenna factors in terms of dB were added to each peak, and the peak heights were then converted into terms of power density in units of mW/cm². Finally, the heights of peak power were arithmetically averaged over the number of spectrum scans made at an individual site.

Experimental accuracy

The accuracy of the data was influenced by several factors. First, the equipment specifications indicated that the accuracy of the receiving and display system, including the plotter, could be set to about ± 3 dB. Second, the antennas used in the experiment were all polarization dependent to some extent. One could assume that all measurements were taken in the far field of the emitters and, thus, that the electric field could be projected into some combination of vertical and horizontal polarization. For example, the 41-inch rod antenna used for

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all AM broadcast and high-frequency communications measurements responded only to vertical polarization, and the broadband dipole used for all FM, VHF, and UHF measurements responded only to horizontal polarization. These directions, however, correspond to the typical polarizations of the transmitters, and a maximum error can be estimated at around ± 6 dB.

Another influencing factor is the variation of the received signals. During the operations of the third program, a constant check was made of the percent deviation of individual peak heights from their average. The maximum variation in intensities, approximately ± 6 dB, occurred for a pulsed radar installation. The cause of such a diversity of received signals can be attributed to the modulation, the duty factors, and the relative direction of the emitting sources at the time of reception. For example, if the receivers were monitoring a pulsed signal only during its dead time, no intensity would be detected for that particular frequency scan. If the monitoring coincided with the on-time, a maximum would be detected. A large number of scans would be needed to arrive at a good average. The typical variation for the received signals was about ± 3 dB.

The final factor affecting the accuracy of the experiment was the diurnal variation of signal strength. It is possible that the 1 day or 8 hours measured at a particular monitoring site was only grossly representative of the normal average RF exposures at the location. However, since most of the power densities detected originated from commercial broadcast equipment which operated daily and emitted the most power during working hours, the variation of total power densities from day to day would be negligible. The only noticeable variation of signals came in the increased use of the amateur "ham" radio bands at night. These level changes were insignificant. It should also be noted that all broadband noise, whether man-made, atmospheric, galactic, etc., has been considered insignificant compared to the levels of the narrowband sources, and therefore, has been ignored.

Considering the above influences, the experimental results can be considered accurate to within ± 15 dB.

Results

The results of the first three computer programs consisted of a listing of frequencies and the peak power densities of specific narrowband emitters averaged over a number of spectrum scans throughout the day at a given site.

True average values of power densities are functions of the modulation and duty factors of the signal source. These would fall anywhere from 2 to 4 dB below the peak values for AM or FM emitters to as much as 30 dB or more below for pulsed equipment such as radar installations. The peak levels, thus, represent a worst possible case.

The test results indicate that the greatest proportion of the intensity measured was emitted in the commercial broadcast bands. The average number of received signals per frequency group at Washington Mall test site (*11*) was approximately 7.0. This is typical of the number of signals occupying the spectrum and their intensities in the 250 spectrum scans of this experiment. The accuracy of these intensities is within that discussed above; the accuracy of the frequency location of each peak is listed in reference (*11*).

The frequency and peak power density level were relisted for each data peak in the final program. The levels were summed arithmetically over four relevant frequency bands, and a summation was made over the entire frequency range of 20 Hz to 10 GHz. A summation was also made over the commercial broadcast bands, AM, FM, VHF, and UHF, for each of the ten sites. The results of these operations are shown at the end of the article in tables 2 through 11 for each site. In this summing operation, each power term was directly proportional to the square of the associated electric field. Theoretically, true instantaneous total power density should include the cross terms that arise from the squaring of a sum. On the average, however, these products will be very small, and since one peak usually dominates in each band, the cross terms will also be negligible compared to the square of the dominant signal at the given instant of the measurement.

The highest intensity was measured at National Airport where a peak level of 7.7×10^{-3} mW/cm^2 at 2.9 GHz was noted. This was attributed to one of the high-powered, pulsed, search-radar installations present in the vicinity of the airport. The low duty cycle of such an installation would indicate an average power density around 7 × 10^{-6} mW/cm^2 at the actual test site.

The next highest value, which occurred in the AM frequency range, was measured at Holy Cross Hospital near the Capital Beltway. A peak power density of 2.4 × 10^{-4} mW/cm^2 was measured at a frequency of 1.1 MHz which would fall within 4 dB of the average. This frequency corresponds to the 1 kW AM tower of WQMR which is located approximately 300 meters from the test site. The measured power density is in general agreement with the predicted value, which is calculated as follows:

$$P_D = \frac{PG}{4\pi R^2}$$

where

P_D = power density at distance R from antenna, and

G = gain of antenna = 1.64

therefore,

$$P_D = \frac{(1\ \text{kW})(1.64)}{4\pi(300\ \text{m})^2} = \frac{(10^3\ \text{W})(1.64)}{4\pi(90{,}000\ \text{m}^2)} = 1.4 \times 10^{-4}\ \text{mW/cm}^2$$

The 1 kW output of WQMR, when compared to 50 kW AM stations and MW radar sites, is small. The high intensity measured was a result of the extremely close proximity to the test site. In the case of the other sites, high-powered AM or FM transmitters were more than 1 mile from the test site. Thus, a relatively low-powered source which is directional and/or located in close proximity to a residential area can cause a higher exposure than major antennas which are more isolated.

The two readings described above overwhelmed all other signals in the sum at their particular sites. These sites yielded the highest total power densities of the experiment. The total power density for National Airport was 7.9 × 10^{-3} mW/cm^2, and the total for Holy Cross Hospital was 3.9 × 10^{-4} mW/cm^2.

A summation of power densities from narrowband sources was made over four "biologically relevant" portions of the total spectrum measured. The divisions were made on the basis of percent absorption of radiation by the human body (*12*). Table 12 shows these biologically relevant frequency bands and the absorption percentages. The maximum observed power densities of radiation in each of the bands in the D.C. urban area are summarized in table 13.

Table 12. Relative absorption cross sections of electromagnetic radiation in the human body

Frequency (MHz)	Maximum absorption (percent)
<400	<50
400– 1,000	50–100
1,000– 3,000	20–100
3,000–10,000	>50

Table 13. Maximum observed power density levels in four biologically relevant frequency bands

Frequency (MHz)	Site	Power density exposure (mW/cm^2)
Less than 400	Holy Cross Hospital	3.9 x 10^{-4}
400– 1,000	Montgomery Mall	1.1 x 10^{-6}
1,000– 3,000	National Airport	7.7 x 10^{-3}
3,000–10,000	National Airport	1.4 x 10^{-4}

Conclusions

The peak ambient radiation originating from manmade RF sources at the ten sites monitored in the Washington, D.C. area approached a maximum of 10^{-2} mW/cm^2. This power density may be considered accurate to within 15 dB. If high-powered low-duty-cycle, pulsed radar signals are considered abnormal and excluded from the totals, the maximum was nearly 10^{-3} mW/cm^2; and if one is concerned only with average exposure, the maximum would fall even lower. The average background thus is at least two to three orders of magnitude less than any published United States recommendations for exposure to RF radiation. Almost the entire power density measured at the monitored sites could be attributed to individual or a combination of commercial broadcasting and high-

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powered radar installations in close proximity to the test site (i.e. within 1 mile).

On the basis of these results, it is recommended that no further broadband environmental surveys be carried out at this time unless prior calculations indicate their need. Individual AM and FM radio and VHF, UHF, and radar transmitters, however, should be closely monitored to determine exposure levels at populated sites in proximate areas.

Site 1, Holy Cross Hospital

Holy Cross hospital is a 344-bed medical facility located just off Forest Glen Road in Silver Spring, Md. The hospital employs approximately 500 persons and occupies a 10.4-acre site, several hundred yards north of I-495 (the Capital Beltway).

A self-contained emergency power generating station, capable of putting out a total of 375 kW of electrical energy, is maintained adjacent to the south side of the building. A test site was selected on the east side of this generating station.

Table 2. Total power densities[a] over biologically significant frequency ranges at site 1, Holy Cross hospital

Frequency (MHz)	Total power density (mW/cm²)
0-400	3.9×10^{-4}
400-1,000	4.3×10^{-9}
1,000-3,000	5.8×10^{-10}
3,000-10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	3.5×10^{-4}
Radio-FM	88 MHz—108 MHz	4.3×10^{-6}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	3.9×10^{-7}
TV-UHF	470 MHz—890 MHz	3.9×10^{-9}

[a] Total power density: 3.9×10^{-4} mW/Cm².

Site 2, Montgomery Mall

Montgomery Mall is one of the newest and largest shopping centers in the Washington metropolitan area. It consists of a completely enclosed shopping area containing 60 stores and shops and serves approximately 15,000 customers during weekday hours. The Mall is located 1 mile west of I-270 on Democracy Boulevard in Bethesda, Md., and covers an area of 55 acres, including parking facilities.

The test site was located in a parking area approximately 100 yards from the south entrance of a store, in the southeast corner of the Mall. Pedestrian traffic in the immediate area of the site was fairly light, as was vehicular traffic.

Table 3. Total power densities[a] over biologically significant frequency ranges: site 2, Montgomery Mall

Frequency (MHz)	Total power density (mW/cm²)
0—400	2.1×10^{-4}
400—1,000	1.1×10^{-6}
1,000—3,000	1.8×10^{-7}
3,000—10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	2.1×10^{-4}
Radio-FM	88 MHz—108 MHz	1.1×10^{-4}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	1.7×10^{-7}
TV-UHF	470 MHz—890 MHz	1.1×10^{-6}

[a] Total power density: 2.2×10^{-4} mW/cm².

Site 3, Cameron Station

Cameron Station is located in a semi-industrial area of southwest Alexandria, Va. Several high-rise apartment buildings are situated in the area of the site, but most of the area in the immediate vicinity is zoned for small business and service establishments. The Cameron Station Quartermaster Depot is also located here and serves as the official purchasing agency for the Washington, D.C., Military District of the U.S. Army.

The test site was located in a parking lot at the southwest corner of Duke and Pickett Streets.

Table 4. Total power densities[a] over biologically significant frequency ranges: site 3, Cameron Station

Frequency (MHz)	Total power density (mW/cm²)
0—400	3.2×10^{-5}
400—1,000	1.3×10^{-6}
1,000—3,000	3.4×10^{-8}
3,000—10,000	Below receiver sensitivity

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Table 4. Total power densities over radio and television bands—continued

Band	Frequency	Total power density (mW/cm^2)
Radio-AM	535 kHz—1.605 MHz	3.1×10^{-6}
Radio-FM	88 MHz—108 MHz	5.5×10^{-9}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	3.8×10^{-9}
TV-UHF	470 MHz—890 MHz	9.7×10^{-10}

[a] Total power density: 3.2×10^{-6} mW/cm^2.

Site 4, Andrews Air Force Base

Andrews Air Force Base is located in Prince Georges County, Md., just off the southeast corridor of the Capital Beltway (I-495) and approximately 11 miles from downtown Washington, D.C. The base covers an area of 4,250 acres and employs over 15,000 military and civilian personnel.

Andrews' mission is to supply all operational and logistic support to military personnel in the greater Washington, D.C. vicinity and also to provide associated training to meet current performance standards. Thirty tenant military units are stationed at Andrews AFB including the Air Force System Command, the Naval Air Reserve Facility, and the Naval and Marine Reserve Training Facility.

The test site was located in the Andrews Manor Shopping Center, across from the main gate at the Air Force Base.

Table 5. Total power densities[a] over biologically significant frequency ranges: site 4, Andrews Air Force Base

Frequency (MHz)	Total power density (mW/cm^2)
0—400	2.2×10^{-5}
400—1,000	3.7×10^{-9}
1,000—3,000	9.3×10^{-8}
3,000—10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm^2)
Radio-AM	535 kHz—1.605 MHz	9.8×10^{-6}
Radio-FM	88 MHz—108 MHz	8.4×10^{-6}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	3.5×10^{-6}
TV-UHF	470 MHz—890 MHz	3.7×10^{-9}

[a] Total power density: 2.2×10^{-5} mW/cm^2.

Site 5, Washington Mall

Washington Mall is an open, grassy area extending from the Capital Building to the Washington Monument. The numerous government offices and tourist attractions surrounding the Mall render it an area of very high pedestrian traffic.

The test site was located on the Mall, across from the National Gallery of Art, on the northwest corner of the intersection of Sixth and Adams Streets, N.W.

Table 6. Total power densities[a] over biologically significant frequency ranges: site 5, Washington Mall

Frequency (MHz)	Total power density (mW/cm^2)
0—400	2.6×10^{-6}
400—1,000	4.9×10^{-10}
1,000—3,000	1.1×10^{-7}
3,000—10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm^2)
Radio-AM	535 kHz—1.605 MHz	2.6×10^{-6}
Radio-FM	88 MHz—108 MHz	2.2×10^{-8}
TV-VHF	54 MHz— 73 MHz 75.4 MHz— 88 MHz and 174 MHz—216 MHz	5.3×10^{-8}
TV-UHF	470 MHz—890 MHz	3.0×10^{-11}

[a] Total power density: 2.6×10^{-6} mW/cm^2.

Site 6, Brentwood Park

Brentwood Park is a rambling residential area in northeast Washington, D.C., surrounded mainly by lower-middle class dwelling units and apartment projects. A short distance away, in the Florida Avenue markets, are many of the warehouses and distribution centers of the city's food industry.

The test site was located in an open field on the Gallaudet College campus on Florida Avenue at 7th Street, N.E.

Table 7. Total power densities[a] over biologically significant frequency ranges: site 6, Brentwood Park

Frequency (MHz)	Total power density (mW/cm^2)
0—400	8.6×10^{-6}
400—1,000	Below receiver sensitivity
1,000—3,000	3.0×10^{-8}
3,000—10,000	Below receiver sensitivity

Table 7. Total power densities over radio and television bands—continued

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	8.6×10^{-5}
Radio-FM	88 MHz—108 MHz	Below receiver sensitivity
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	Below receiver sensitivity
TV-UHF	470 MHz—890 MHz	Below receiver sensitivity

[a] Total power density: 8.6×10^{-5} mW/cm².

Site 7, Sibley Memorial Hospital

Sibley Memorial Hospital is located just inside Washington, D.C. line on MacArthur Boulevard, N.W. The hospital is situated less than a quarter of a mile from the Potomac River in a semiresidential area. Several radio and television transmitting stations are located within a 2-mile radius of Sibley Hospital.

The test site was located on a small hill on the northwest side of the hospital.

Table 8. Total power densities[a] over biologically significant frequency ranges: site 7, Sibley Memorial Hospital

Frequency (MHz)	Total power density (mW/cm²)
0—400	6.8×10^{-6}
400—1,000	1.0×10^{-7}
1,000—3,000	4.0×10^{-8}
3,000—10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	3.2×10^{-6}
Radio-FM	88 MHz—108 MHz	1.6×10^{-6}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	7.8×10^{-7}
TV-UHF	470 MHz—890 MHz	1.0×10^{-7}

[a] Total power density: 7.0×10^{-6} mW/cm².

Site 8, Duval Senior High School

DuVal Senior High School is located at Glenn Dale and Telegraph Roads in Prince Georges County, Md., near the Goddard Space Flight Center (NASA) in Greenbelt, Md. This area is approximately 8 miles from downtown Washington, D.C. and is almost exclusively a residential area.

The test site was located in the north parking lot area of the high school.

Table 9. Total power densities[a] over biologically significant frequency ranges: site 8, Duval Senior High School

Frequency (MHz)	Total power density (mW/cm²)
0—400	6.6×10^{-7}
400—1,000	4.3×10^{-10}
1,000—3,000	8.8×10^{-9}
3,000—10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	4.1×10^{-7}
Radio-FM	88 MHz—108 MHz	4.5×10^{-9}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	2.8×10^{-9}
TV-UHF	470 MHz—890 MHz	4.3×10^{-10}

[a] Total power density: 7.5×10^{-7} mW/cm².

Site 9, Washington National Airport

Washington National Airport is the major airline terminal serving the surrounding metropolitan area and handles the takeoffs and landings of anywhere from 350 to 550 aircraft daily. During July 1969 alone, nearly 1.5 million commercial passengers passed through National Airport.

Located at the airport is a wide range of communications transmitters, as well as Flight Control and Ground Control Approach radar systems. National Airport is located in Arlington County, Va., on the George Washington Memorial Parkway, just outside of Alexandria, Va., and directly south across the Potomac River from the Jefferson Memorial. The test site was located in a parking lot reserved for the Diplomatic Corps.

Table 10. Total power densities[a] over biologically significant frequency ranges: site 9, Washington National Airport

Frequency (MHz)	Total power density (mW/cm²)
0—400	8.3×10^{-6}
400—1,000	4.7×10^{-6}
1,000—3,000	7.7×10^{-8}
3,000—10,000	1.4×10^{-6}

Table 10. Total power densities over radio and television bands—continued

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	7.0×10^{-4}
Radio-FM	88 MHz—108 MHz	9.6×10^{-4}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	1.8×10^{-3}
TV-UHF	470 MHz—890 MHz	4.6×10^{-6}

[a] Total power density: 7.9×10^{-3} mW/cm².

Site 10, Darnestown, Md.

Darnestown, Md., is a small rural community approximately 9 miles west of Rockville, Md., on Route #28, 20 miles northwest of Washington, D.C. Darnestown has no industry of its own, but is surrounded by farming areas and several residential developments. Four miles east of the town on Route #28 is an Army installation housing a NIKE/AJAX anti-aircraft system which includes air search and guidance radars.

The actual site was at the house of Mr. Donald R. J. White on Springfield Drive, which intersects Route #112 about 1 mile south of Darnestown.

Table 11. Total power densities[a] over biologically significant frequency ranges: site 10, Darnestown, Md.

Frequency (MHz)	Total power density (mW/cm²)
0—400	2.6×10^{-7}
400—1,000	1.1×10^{-5}
1,000—3,000	2.4×10^{-4}
3,000—10,000	Below receiver sensitivity

Total power densities over radio and television bands

Band	Frequency	Total power density (mW/cm²)
Radio-AM	535 kHz—1.605 MHz	9.2×10^{-6}
Radio-FM	88 MHz—108 MHz	1.2×10^{-6}
TV-VHF	54 MHz— 73 MHz and 75.4 MHz— 88 MHz and 174 MHz—216 MHz	3.2×10^{-6}
TV-UHF	470 MHz—890 MHz	1.1×10^{-5}

[a] Total power density: 2.5×10^{-4} mW/cm².

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, February 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

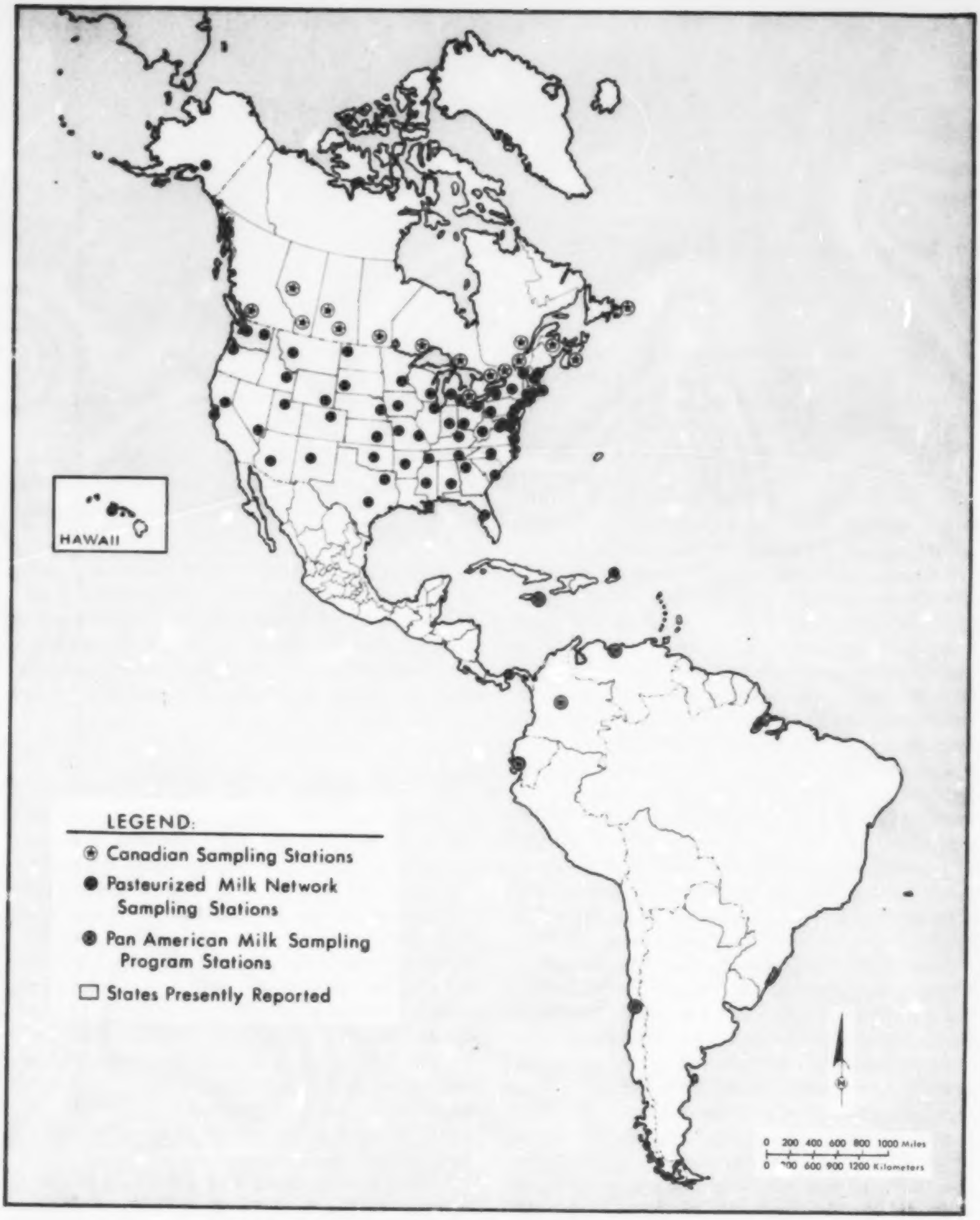
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.61 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the experiment.

The accuracy results of this experiment for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analysis of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analyses varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 shows whether raw or pasteurized milk was collected. An analysis (7) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (7). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (3). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (3). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for those precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the

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Table 2. Concentrations of radionuclides in milk for February 1972 and 12-month period, March 1971 through February 1972

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	7	0	9
Alaska:	Palmer[c]	P	4	5	21	13
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	NA	12	13	14
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	4	0	0
	Del Norte	P	10	12	10	11
	Fresno	P	0	2	11	5
	Humboldt	P	4	3	13	6
	Los Angeles	P	1	2	0	3
	Mendocino	P	12	7	10	9
	Sacramento	P	2	3	0	4
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	6
	Shasta	P	3	3	0	6
	Sonoma	P	2	3	0	7
Colo:	Denver[c]	P	NA	5	0	8
	East	R	(d)		[e]0	[e]0
	Northeast	R	(d)		[e]0	[e]1
	Northwest	R	(d)		NS	[e]0
	South Central	R	(d)		NS	
	Southeast	R	(d)		NS	[e]0
	Southwest	R	(d)		[e]0	[e]2
	West	R	(d)		NS	[e]0
Conn:	Hartford[c]	P	NA	7	17	10
	Central	P	6	7	9	14
Del:	Wilmington[c]	P	NA	8	0	4
D.C:	Washington[c]	P	NA	8	13	9
Fla:	Tampa[c]	P	6	5	37	42
	Central	R	6	6	44	43
	North	R	5	9	18	24
	Northeast	R	6	7	41	37
	Southeast	R	8	7	98	56
	Tampa Bay area	P	6	6	31	41
	West	R		11	18	20
Ga:	Atlanta[c]	P	NA	10	19	16
Hawaii:	Honolulu[c]	P	2	3	0	2
Idaho:	Idaho Falls[c]	P	6	5	0	2
Ill:	Chicago[c]	P	10	7	16	10
Ind:	Indianapolis[c]	P	NA	7	14	4
	Central	P	8	8	15	13
	Northeast	P	7	7	10	15
	Northwest	P	7	8	15	15
	Southeast	P	8	9	20	15
	Southwest	P	7	9	20	15
Iowa:	Des Moines[c]	P	NA	6	0	2
	Iowa City	P	4	6	10 (2)	11
	Des Moines	P	9	7	0	10
	Little Cedar	P	8	7	11	12
	Spencer	P	6	6	10	12
Kans:	Wichita[c]	P	NA	8	0	2
	Coffeyville	P	NA		NA	
	Dodge City	P	NA		NA	
	Falls City, Nebr	R	NA		NA	
	Hays	P	NA		NA	
	Kansas City	P	NA		NA	
	Topeka	P	NA		NA	
	Wichita	P	NA		NA	
Ky:	Louisville[c]	P	NA	8	16	7
La:	New Orleans[c]	P	12	14	0	16
Maine:	Portland[c]	P	NA	8	27	20
Md:	Baltimore[c]	P	NA	8	0	6
Mass:	Boston[c]	P	6	8	17	12
Mich:	Detroit[c]	P	NA	7	15	10
	Grand Rapids[c]	P	NA	9	19	10
	Bay City	P	6	7	16 (2)	15
	Charlevoix	P	8	10	13 (2)	16
	Detroit	P	6	7	11	10
	Grand Rapids	P	4	6	0	10
	Lansing	P	5	8	12 (2)	16
	Marquette	P	2	8	24 (2)	24
	Monroe	P	2	4	6 (2)	4
	South Haven	P	6	6	6 (4)	9
Minn:	Minneapolis[c]	P	NA	8	19	16
	Bemidji	P	11	9	20	20
	Duluth	P	17	19	28	29
	Fergus Falls	P	10	8	23	17
	Little Falls	P	11	17	25	30
	Mankato	P	5	6	0	12
	Minneapolis	P	12	13	19	17

Footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for February 1972 and 12-month period, March 1971 through February 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES: continued						
Minn:	Rochester	P	6	8	20	14
	Worthington	P	7	6	14	11
Miss:	Jackson[c]	P	NA	13	0	10
Mo:	Kansas City[c]	P	NA	8	0	6
	St. Louis[c]	P	NA	5	0	5
Mont:	Helena[c]	P	NA	6	18	10
Nebr:	Omaha[c]	P	NA	7	0	4
Nev:	Las Vegas[c]	P	NA	2	0	1
N.H:	Manchester[c]	P	NA	8	13	18
N.J:	Trenton[c]	P	NA	8	15	9
N. Mex:	Albuquerque[c]	P	NA	2	0	0
N.Y:	Buffalo[c]	P	7	7	0	7
	New York City[c]	P	NA	8	14	11
	Syracuse[c]	P	NA	7	13	9
	Albany	P	6	6	[d]0	[d]0
	Buffalo	P	NA		[d]0	[d]0
	Massena	P	6	6	[d]0	[d]0
	New York City	P	NA	0	[d]0	[d]0
	Syracuse	P	[d]0	4	[d]0	[d]0
N.C:	Charlotte[c]	P	NA	10	0	12
N. Dak:	Minot[c]	P	NA	9	0	13
Ohio:	Cincinnati[c]	P	NA	6	0	1
	Cleveland[c]	P	NA	7	15	6
Okla:	Oklahoma City[c]	P	NA	6	0	9
Oreg:	Portland[c]	P	5	5	0	6
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	R	NA		NA	
Pa:	Philadelphia[c]	P	NA	8	0	6
	Pittsburgh[c]	P	NA	10	0	6
	Dauphin	P	0	7	15	12
	Erie	P	6	9	14	16
	Philadelphia	P	5	6	14	13
	Pittsburgh	P	6	8	18	14
R.I:	Providence[c]	P	NA	8	0	13
S.C:	Charleston[c]	P	7	9	18	15
S. Dak:	Rapid City[c]	P	NA	6	0	7
Tenn:	Chattanooga[c]	P	NA	8	14	12
	Memphis[c]	P	NA	7	0	7
	Chattanooga	P	NA	9	18	14
	Clinton	R	NA	9	13 (2)	14
	Fayetteville	R	NA	10	7 (2)	6
	Kingston	R	NA	7	18 (2)	10
	Knoxville	P	NA	7	12 (2)	10
	Lawrenceburg	R	NA	5	0	5
	Nashville	P	NA	7	0	8
	Pulaski	R	NA	8	13 (2)	5
Tex:	Austin[c]	P	NA	2	0	0
	Dallas[c]	P	NA	6	0	4
	Amarillo	R	NS	3	NS	0
	Corpus Christi	R	3	5	0	0
	El Paso	R	3	3	0	0
	Fort Worth	R	NS	4	NS	0
	Harlingen	R	NS	4	NS	0
	Houston	R	NS	8	NS	8
	Lubbock	R	5	4	6	0
	Midland	R	NS	3	NS	0
	San Antonio	R	NS	5	NS	0
	Texarkana	R	NS		NS	
	Tyler	R	10	13	0	10
	Wichita Falls	R	NS	7	NS	5
Utah:	Salt Lake City[c]	P	5	5	0	10
Vt:	Burlington[c]	P	NA	6	19	11
Va:	Norfolk[c]	P	NA	8	14	5
Wash:	Seattle[c]	P	NA	5	0	6
	Spokane[c]	P	NA	6	0	6
	Benton County	R	NS	2	NS	0
	Franklin County	R	0	1	0	6
	Sandpoint, Idaho	R	7	12	13	22
	Skagit County	R	6	8	0	10
W. Va:	Charleston[c]	P	NA	8	0	7
Wisc:	Milwaukee[c]	P	NA	6	13	7
Wyo:	Laramie[c]	P	NA	4	0	2

Footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for February 1972 and 12-month period, March 1971 through February 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:						
Alberta:	Calgary	P	NA		18	19
	Edmonton	P	NA		28	24
British Columbia:						
	Vancouver	P	NA		26	25
Manitoba:	Winnipeg	P	NA		23	24
New Brunswick:						
	Fredericton	P	NA		17	22
Newfoundland:						
	St. John's	P	NA		16	31
Nova Scotia:						
	Halifax	P	NA		24	25
Ontario:	Ottawa	P	NA		13	14
	Sault Ste. Marie	P	NA		28	33
	Thunder Bay	P	NA		27	25
	Toronto	P	NA		14	14
	Windsor	P	NA		13	11
Quebec:	Montreal	P	NA		13	18
	Quebec	P	NA		26	29
Saskatchewan:						
	Regina	P	NA		21	17
	Saskatoon	P	NA		23	18
CENTRAL AND SOUTH AMERICA:						
Canal Zone:						
	Cristobal[c]	P	NA	0	0	4
Chile:	Santiago	P	0	0	0	2
Colombia:	Bogota	P	3	1	0	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Mandeville	P	0	4	38	68
Puerto Rico:						
	San Juan[c]	P	NA	4	11	11
Venezuela:						
	Caracas	P	0	0	0	0
PMN network average[f]			6	7	7	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

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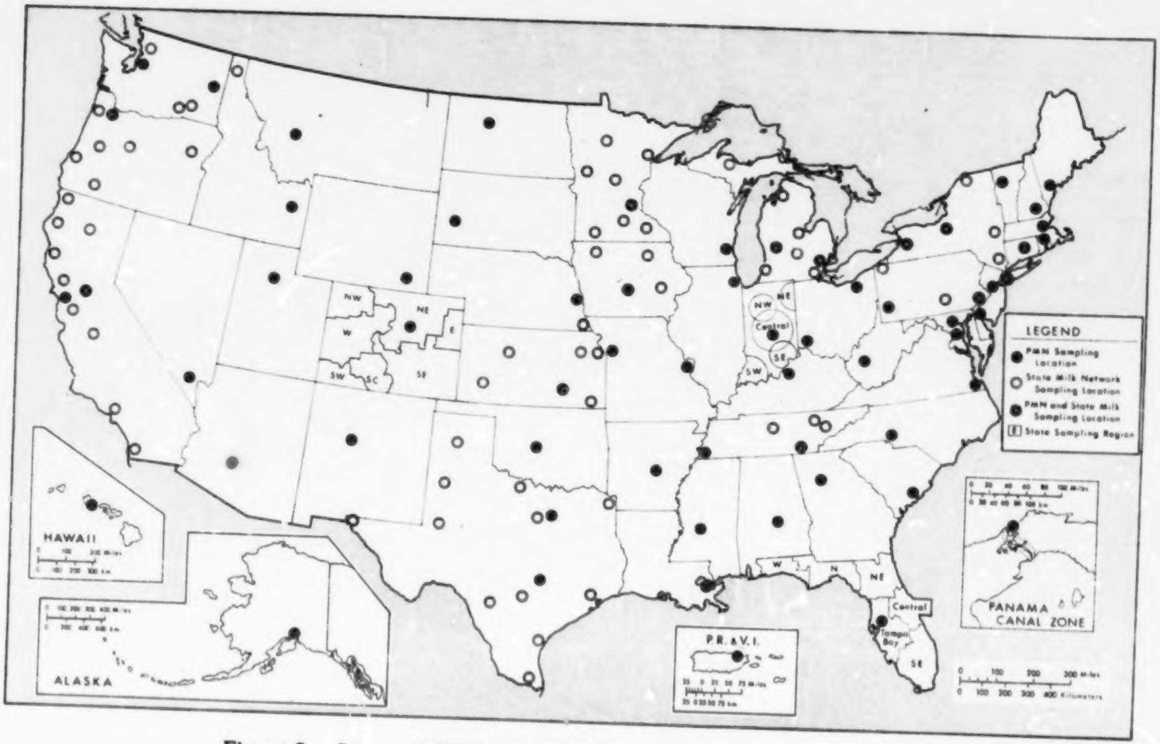
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay

Figure 2. State and PMN milk sampling stations in the United States

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for February 1972 and the 12-month period, March 1971 to February 1972. Except where noted, the monthly average represents a single sample for the sampling location. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for February 1972 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Table 3. Strontium-89, iodine-131,[a] and barium-140 in milk February 1972

Sampling location		Strontium-89[b] (pCi/liter)	Barium-140[b] (pCi/liter)
Calif:	Del Norte (State)	8	
	Mendocino (State)	17	
Colo:	East (State)		14 (4)
	Northeast (State)		50 (2)

[a] No iodine-131 was detected.

[b] These levels may be the result of debris from the nuclear detonation by the People's Republic of China in January 1972.

Number in parentheses indicates number of samples.

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Strontium-90 monthly averages ranged from 0 to 17 pCi/liter in the United States for February 1972, and the highest 12-month average was 19 pCi/liter (Duluth, Minn.) representing 9.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 98 pCi/liter in the United States for February 1972, and the highest 12-month average was 56 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (8) and Jamaica.

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July–December 1970	November 1971
Carbon-14 in Total Diet and Milk	July–December 1970	May 1972
Connecticut Standard Diet	January–December 1970	December 1971
Strontium-90 in Tri-City Diets	January–December 1970	November 1971

Radionuclides in Institutional Diet Samples, October-December 1971 and 1971 Annual Summary

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present, 25 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1, 2*). Extrapolating this information,

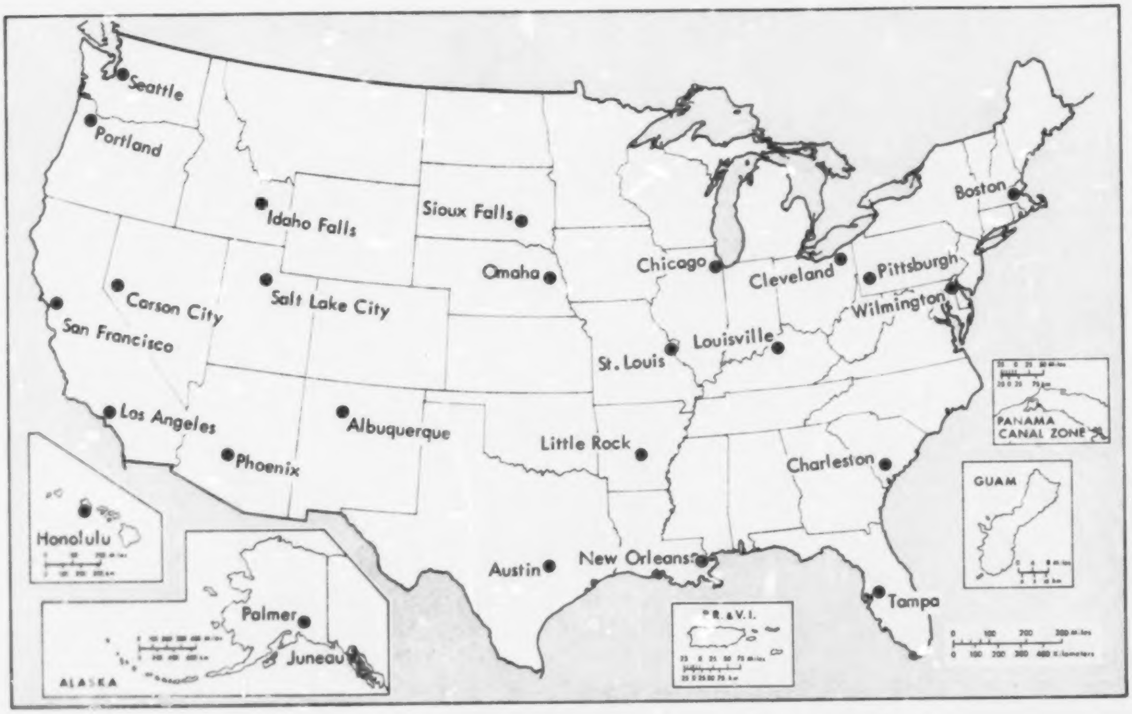
Seattle
Portland
Idaho Falls
Sioux Falls
Boston
Omaha
Chicago
Cleveland
Pittsburgh
Wilmington
Carson City
Salt Lake City
San Francisco
St. Louis
Louisville
Los Angeles
Albuquerque
Little Rock
Phoenix
Charleston
Honolulu
Austin
New Orleans
Tampa
Palmer
Juneau
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
GUAM

Figure 1. Institutional diet sampling locations as of December 1971

estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water—which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the Western Environmental Research Laboratory, Las Vegas, Nev; the Eastern Environmental Radiation Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (*3*).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during October–December 1971. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.70 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1970.

Strontium-90 dietary intake averaged 9 pCi/day during this period. Cesium-137 intake averaged 10 pCi/day. These results fall within Range I as defined by the former Federal Radia-

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children October-December 1971

Location of institution	Month[a] (1971)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	October[b]	1.37	0.7	0.9	1.5	2.0	6	8	0	0
Palmer	October	1.57	.4	.7	1.4	2.3	5	7	0	0
Ariz: Phoenix	October	1.88	.6	1.1	1.8	3.4	5	10	11	21
Ark: Little Rock	October	1.64	.6	1.0	1.6	2.6	7	12	13	21
Calif: Los Angeles	October[b]	1.35	.4	.5	1.2	1.7	5	6	0	0
San Francisco	October[b]	1.42	.6	.8	2.0	2.8	5	7	0	0
Del: Wilmington	October	2.04	.7	1.5	1.6	3.3	8	16	0	0
Fla: Tampa	October	1.65	.5	.8	1.1	1.9	5	8	27	45
Hawaii: Honolulu	October	2.30	.7	1.7	1.7	3.9	4	10	13	30
Idaho: Idaho Falls	October[b]	1.75	.3	.5	1.5	2.6	5	8	11	19
Ill: Chicago	October[b]	.72	.6	.5	1.3	1.0	10	7	0	0
Ky: Louisville	October	2.13	1.1	2.3	1.6	3.3	4	9	0	0
La: New Orleans	October[b]	1.52	.6	.9	1.6	2.4	7	11	17	26
Mass: Boston	October	2.15	.7	1.5	1.5	3.2	7	16	18	39
Mo: St. Louis	October	1.10	.8	.8	1.6	1.7	7	7	0	0
Nebr: Omaha	October[b]	1.97	.8	1.7	1.7	3.4	5	10	0	0
Nev: Carson City	October	1.46	.5	.8	1.4	2.1	5	7	13	19
N. Mex: Albuquerque		NS								
Ohio: Cleveland	October[b]	1.61	.8	1.3	1.5	2.4	5	7	0	0
Oreg: Portland	October[b]	1.89	.5	1.0	1.8	3.4	3	6	0	0
Pa: Pittsburgh	October	2.65	.6	1.6	1.2	3.2	6	15	0	0
S.C: Charleston	October[b]	1.02	.9	.9	1.5	1.6	9	10	20	20
S. Dak: Sioux Falls	October[b]	1.27	1.1	1.4	1.3	1.7	4	5	0	0
Tex: Austin	October[b]	1.94	.8	1.6	1.5	3.0	5	9	0	0
Utah: Salt Lake City	October[b]	2.27	.5	1.1	1.4	3.2	3	6	0	0
Wash: Seattle	October[b]	1.92	.5	1.0	1.8	3.4	3	6	0	0
Institutional average		1.70	0.7	1.1	1.5	2.6	5	9	6	10

[a] Quarterly sample usually collected the first month of the quarter.

[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.

Note: Iodine-131 and barium-140 were not detected at any station during this period. Portland, Oreg. had a strontium-89 concentration of 6 pCi/kg

NS, no sample.

Table 2. 1971 annual average concentration and intake of stable elements and radionuclides in institutional total diets of children [a]

Location of Institution		Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau[b]	1.23	0.6	0.8	1.4	1.8	5	6	5	6
	Palmer	1.45	.4	.5	1.4	2.0	4	6	3	5
Ariz:	Phoenix	1.80	.5	.8	1.5	2.7	2	4	3	5
Ark:	Little Rock	1.41	.6	.9	1.7	2.4	8	11	10	14
Calif:	Los Angeles[b]	1.51	.4	.6	1.2	1.8	3	4	0	0
	San Francisco[b]	1.74	.7	1.2	1.6	2.8	3	5	0	0
Del:	Wilmington	2.11	.6	1.3	1.5	3.1	7	14	8	16
Fla:	Tampa[b]	1.96	.5	1.0	1.3	2.5	5	9	23	44
Hawaii:	Honolulu	2.22	.6	1.2	1.4	3.2	2	4	14	30
Idaho:	Idaho Falls[b]	2.18	.7	1.5	1.6	3.5	9	19	15	33
Ill:	Chicago[b]	1.08	.7	.7	1.5	1.6	8	8	0	0
Ky:	Louisville	2.49	.9	2.1	1.5	3.7	7	17	3	8
La:	New Orleans[b]	1.70	.6	1.1	1.7	2.8	8	14	15	26
Maine:	Portland	1.76	.9	1.5	1.6	2.8	14	25	17	30
Mass:	Boston	2.05	.6	1.3	1.4	2.8	7	14	12	24
Mo:	St. Louis	1.17	.8	.9	1.4	1.6	7	8	0	0
Nebr:	Omaha[b]	2.09	.9	1.8	1.7	3.5	7	15	3	6
Nev:	Carson City	1.47	.7	1.0	1.4	2.0	3	4	3	5
N Mex:	Albuquerque	1.75	.7	1.1	1.2	2.1	0	0	0	0
Ohio:	Cleveland[b]	1.52	.8	1.1	1.6	2.4	9	13	7	11
Oreg:	Portland[b]	1.87	.6	1.0	1.9	3.5	3	6	3	6
Pa:	Pittsburgh[b]	2.46	.5	1.3	1.2	3.0	7	16	4	9
S.C:	Charleston[b]	1.70	.7	1.2	1.4	2.4	7	12	18	30
S.Dak:	Sioux Falls[b]	1.15	.9	1.0	1.4	1.6	8	9	0	0
Tex:	Austin[b]	1.73	.8	1.3	1.5	2.5	3	6	0	0
Utah:	Salt Lake City[b]	2.16	.5	1.1	1.2	2.6	1	3	4	9
Wash:	Seattle[b]	2.00	.6	1.2	1.6	3.2	3	6	3	6
Institutional average		1.77	0.7	1.2	1.5	2.6	6	10	6	11

[a] Iodine-131 and barium-140 were not detected at any station during this period. Strontium-89 was detected as follows: Seattle, Wash.—6 pCi/kg in July, and Portland, Oreg.—6 pCi/kg in October.

[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.

tion Council (4). Barium-140 and iodine-131 concentrations were below detectable levels. Strontium-89 was detected in Portland, Oreg.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2 standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140, 10 pCi/kg; cesium-137, 10 pCi/kg.

Annual average radionuclide concentrations and intakes are presented in table 2 for all stations. During 1971, the annual average intake for these institutions was 1.77 kg/day as compared to the network average of 1.86 kg/day observed from 1961 through 1970. The average levels of radionuclide concentrations are similar to those of previous years.

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Recent coverage in Radiation Data and Reports:

Period	Issue
October-December 1970	May 1971
January-March 1971	September 1971
April-June 1971	November 1971
July-September 1971	April 1972

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
Colorado River Basin	1968	March 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1970	December 1971
Michigan	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, *HASL*	January-June 1971	April 1972
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	October-December 1971	May 1972
Washington	July 1969-June 1970	March 1972
New York	July-December 1970 and January-June 1971	May 1972

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Gross Radioactivity in Surface Waters of the United States October 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Program (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, it is intended to reinitiate this activity as a monthly report series. The unpublished data for the time

Table 1. Gross radioactivity in U.S. surface waters, October 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
Arkansas River:									
Ponca City, Okla	1	6		5		19		11	
Clinch River:									
Kingston, Tenn	[a]4	<0.4	(<0.2-1)	<0.8	(<0.2-2)	2.5	(1-3)	5.2	(4-7)
Colorado River:									
Moab, Utah (above Mill Creek)	[a]4	<3.1	(<.2-9)	12.5	(6-22)	4.8	(3-8)	28.2	(15-54)
Moab, Utah (below Highway Bridge)	[a]4	<3.3	(<.2-10)	12.5	(8-18)	7.2	(2-15)	34.5	(23-55)
Silt, Colo	1	<.2				5		12	
Dolores River:									
Bedrock, Colo	[a]4	4.5	(1-12)	18.2	(14-26)	11.0	(5-15)	33.8	(18-55)
Gateway, Colo	[a]4	3.2	(1-8)	7.0	(2-18)	11.0	(4-17)	33.8	(10-96)
Green River:									
LaBarge, Wyo	[a]2	2.0	(2-2)	5.0	(5-5)	3.0	(3-3)	7.0	(6-8)
Mississippi River:									
Burlington, Iowa	1	1		1		3		6	
Vicksburg, Miss	1	2		<.4		6		4	
West Memphis, Ark	1	1		2		3		9	
Ohio River:									
Cincinnati, Ohio	[a]4	<1.3	(<.2-2)	<2.3	(<.2-3)	2.5	(1-3)	6.5	(6-7)
Red River:									
Denison, Tex	1	1		4		<2		8	
Rio Grande:									
Brownsville, Tex	1	1		6		4		22	
Laredo, Tex	1	2		4		5		10	
Roanoke River:									
John Kerr Dam, Va	[a]4	<.2	(<.2-<.2)	<.2	(<.2-<.2)	2.2	(1-5)	4.8	(4-5)
Sabine River:									
Ruliff, Tex	1	1		.7		4		6	
St. Lawrence River:									
Massena, N.Y	[a]3	<.2	(<.2-<.2)	<.5	(1-5)	2.7	(1-5)	4.7	(2-7)
San Juan River									
Bluff, Utah	1	1		1		9		5	
San Miguel River:									
Naturita, Colo	[a]4	<.2	(<.2-<.2)	1.5	(1-2)	<3.0	(<0.2-5)	10	(6-14)
Uravan, Colo. (above)	[a]4	<.5	(<.2-1)	<1.5	(<.2-3)	3.5	(1-6)	11	(6-14)
Uravan, Colo. (below)	[a]4	1.5	(1-2)	3.8	(3-5)	4.8	(1-6)	11	(4-15)
Susquehanna River:									
Holtwood, Pa	1	<.2		1		5		7	
Verdigris River:									
Nowata, Okla	1	2		<1		5		5	
Virgin River:									
St. George, Utah	1	6		4		16		32	

[a] Where more than one sample is analyzed during the month, the minimum and maximum are in parentheses.

Table 2. Radioactivity in surface waters January-March 1971

River and location	Strontium-90ᵃ (pCi/liter)
Allegheny River:	
Pittsburgh, Pa	1.2 ±0.2
Arkansas River:	
Ponca City, Okla	1.3 ± .2
Beaver River:	
New Brighton, Pa	1.6 ± .1
Big Sandy River:	
Wayne County, W. Va	.6 ± .1
Big Sioux River:	
Sioux Falls, S. Dak	1.4 ± .2
Clinch River:	
Kingston, Tenn	2.0 ± .1
Great Miami River:	
American Material Bridge, Hamilton, Ohio	.4 ± .1
Liberty-Fairfield, Ohio	.7 ± .2
Lost Bridge, Ohio	.6 ± .1
Sellars Road Bridge, Hamilton, Ohio	.5 ± .1
Guyandotte River:	
Guyandotte, W. Va	1.1 ± .2
Kanawha River:	
Winfield Dam, W. Va	.5 ± .2
Kentucky River:	
Dam No. 1	.6 ± .1
Licking River:	
Covington, Ky	.4 ± .2
Little Miami River:	
Cincinnati, Ohio	1.5 ± .2
Mississippi River:	
Burlington, Iowa	1.3 ± .1
West Memphis, Ark	.8 ± .1
Vicksburg, Miss	.9 ± .2
Missouri River:	
Yankton, S. Dak	1.0 ± .1
Monongahela River:	
Pittsburgh, Pa	1.6 ± .2
Muskingum River:	
Dam No. 2, Mich	1.1 ± .1
Ohio River:	
Addison, Ohio	.6 ± .2
Anderson Ferry, Ohio	.7 ± .1
Ashland, Ky	.8 ± .1
Cincinnati, Ohio	1.1 ± .2
Eldean Mills, Ohio	.9 ± .1
Gallipolis Dam	.5 ± .2
Greenup Dam	.6 ± .1
Ironton, Ohio	.6 ± .1
Madison, Ind	6 ± .1
Marietta, Ohio	2.1 ± .3
Markland Dam	.6 ± .1
Maysville, Ky	.9 ± .1
Meldahl Dam	.9 ± .1
Miami Fort	.6 ± .1
New Martinsville, W. Va	.7 ± .1
Old Lock No. 19, W. Va	.9 ± .2
Portsmouth, Ohio	.7 ± .1
Warwood, W. Va	1.0 ± .2
Wheeling, W. Va	.7 ± .2
Red River:	
Denison, Tex	2.1 ± .1
Index, Ark	1.9 ± .2
Rio Grande:	
Brownsville, Tex	1.1 ± .1
Laredo, Tex	.8 ± .1
Roanoke River:	
John Kerr Dam, Va	.5 ± .2
Sabine River:	
Ruliff, Tex	1.0 ± .2
St. Lawrence River:	
Massena, N.Y	1.8 ± .2
St. Mary's River:	
Sault Ste. Marie, Mich	.6 ± .1
Trinity River:	
Livingston, Tex	2.0 ± .2
Verdigris River:	
Nowata, Okla	1.8 ± .1
Whitewater River: (Ohio)	
Suspension Bridge	.8 ± .1

ᵃ The error term is only the counting error expressed at the 1-sigma level.

interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from 17 rivers during October 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Table 2 presents the strontium-90 results on samples collected and composited from 26 rivers during the second quarter of the 1971 water year (January-March 1971). The analytical procedures used for determining strontium-90 are described in *Radionuclide Analysis of Environmental Samples* (*2*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*3*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

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Radioactivity in California Waters,[1] January-December 1970

Bureau of Radiological Health, State of California
Department of Public Health

The Bureau of Radiological Health of the State Department of Public Health has maintained a program of domestic water sampling for radioanalyses since 1960. Radioactivity in the water supplies consists of the natural radioactivity, the contribution from fallout, and in a few instances, the activity added by sewage discharges and industrial effluents. The California Domestic Water Network stations are shown in figure 1.

The monitoring program consists primarily of monthly sampling of domestic water at the point of consumption (at the tap) and analyzing them for gross beta radioactivity. Fourteen of the 20 locations are surface water supplies, three are wells, two are Ranney wells, and one is a spring.

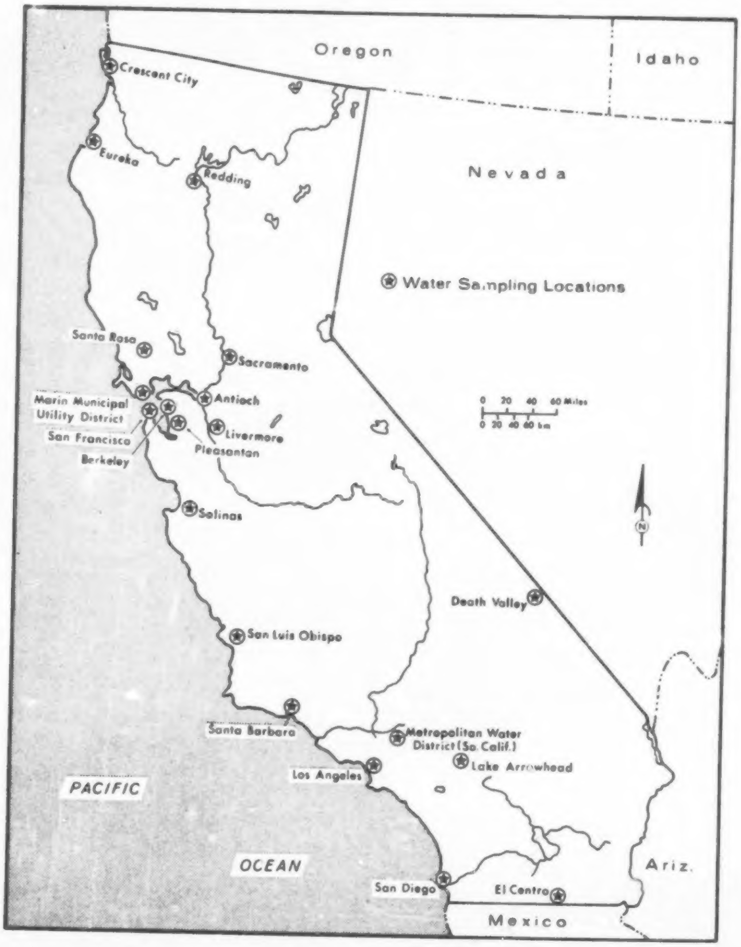
Oregon
Idaho
Nevada
Water Sampling Locations
0 20 40 60 Miles
0 20 40 60 km
N
Crescent City
Eureka
Redding
Santa Rosa
Sacramento
Marin Municipal Utility District
Antioch
San Francisco
Livermore
Berkeley
Pleasanton
Salinas
Death Valley
San Luis Obispo
Santa Barbara
Metropolitan Water District (So. Calif.)
Lake Arrowhead
Los Angeles
PACIFIC
OCEAN
San Diego
El Centro
Ariz.
Mexico

Figure 1. California Domestic Water Network

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[1] Data from State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704

The purpose of this program is to determine the radioactivity of the water. Therefore, any process that might remove radioactivity from the raw water results in a product called treated water. This would include water issuing from a water treatment plant that includes coagulation, sedimentation, filtration, etc. Chlorination is not considered as treatment from a radiological viewpoint. Well waters, including springs and Ranney wells, are usually pumped directly to the distribution system with nothing more than chlorination, and are considered as raw water. It is not implied by the use of the words "raw" and "treated" that the waters are not potable or bacterially safe.

Under the present sampling schedule, monthly 500 milliliter samples are collected by the purveyor of 20 water supplies and sent to the Sanitation and Radiation Laboratory at Berkeley. The samples are evaporated to dryness and the solids analyzed for gross beta radioactivity. In addition, the purveyor collects a yearly composite which is analyzed for specific radionuclides.

Analytical procedures

Radioanalyses of the water samples are made by the Sanitation and Radiation Laboratory of the State Department of Public Health. Measurements of gross beta radioactivity on the monthly samples are made with a windowless, gas-flow proportional counter. The yearly composites are collected throughout the year to make a 5-gallon sample. The entire sample is reduced to dryness. A gamma scan is made on the dry solids with a 10-by 10-cm (4-by 4-inch) sodium iodide (thallium activated) detector. Eight radionuclides are determined. Radiochemical analyses are performed to obtain radium and strontium-90 values. Analytical procedures are those recommended by the Environmental Protection Agency (*1*).

Sewage samples

Sewage samples are collected from 20 treatment plants throughout the State (figure 2). Many of the cities used as sampling locations in this program are the same as those in the domestic water sampling program. Results of analyses of sewage effluent and sludge samples provide a means of assuring that industrial radioactive wastes discharged into sewage systems do not become excessive. The surveillance of sewage assumes greater importance as isotope licenses become more numerous and as the quantity of radioactive material per user increases. Analysis procedures for sewage effluents are the same as the method used for domes-

Table 1. Gross beta radioactivity in California domestic waters, January-December 1970

Sampling station	Type[a]	Concentration (pCi/liter)												
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
Antioch	Treated	NS	NS	NS	NS	NS	NS	1	12	5	7	6	8	7
Arrowhead Lake	Raw	NS	23	0	NS	7	NS	0	8	NS	14	7	8	8
Berkeley—East Bay Municipal District	Treated	7	0	4	2	2	0	3	8	9	3	4	3	4
Crescent City	Ranney well	0	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1
Death Valley	Spring	35	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	35
El Centro[b]	Treated	NS	27	9	17	22	9	NS	NS	9	33	53	0	20
Eureka	Treated	14	13	2	0	7	0	3	8	3	5	14	14	7
Livermore	Well	0	6	0	9	5	20	6	2	21	15	16	0	8
Los Angeles	Raw	16	27	21	18	9	0	NS	18	27	23	7	NS	17
Marin Municipal Water District	Treated	27	21	8	14	14	17	4	3	0	17	7	3	11
Metropolitan Water District of Southern California[b]	Treated	46	17	18	58	45	29	158	71	33	20	18	80	50
Pleasanton	Well	8	5	7	9	1	0	3	0	0	6	3	4	4
Redding	Treated	0	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	0
Sacramento	Treated	NS	NS	NS	4	NS	NS	NS	4	0	2	8	9	5
Salinas	Well	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
San Diego[b]	Treated	NS	NS	NS	NS	NS	11	5	33	43	16	0	33	20
San Francisco	Raw	0	8	4	15	NS	NS	NS	5	NS	2	11	12	7
San Luis Obispo	Treated	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Santa Barbara	Treated	4	14	1	3	2	0	12	NS	NS	NS	NS	NS	5
Santa Rosa	Ranney well	3	13	9	12	0	21	13	9	NS	23	0	5	10

[a] All waters are surface water unless listed as well, spring or Ranney well; treated water means complete treatment, (note: chlorination is not considered as treatment); well waters are pumped direct from the well to the customer with or without chlorination; Ranney Well waters are pumped direct from the well to the customer with or without chlorination; the use of words raw and treated does not imply the waters are not potable or not bacterially safe. The word "treated" implies that the water has been processed and has possibly changed the radioactive content of the water.

[b] Water from Colorado River.

NS, no sample.

Table 2. Radionuclides in California domestic waters, January-December 1970

Sampling station	Radionuclide concentration (pCi/liter)							
	Radium-226	Potassium-40	Manganese-54	Zirconium-niobium-95	Cesium-137	Cerium-141, -144	Strontium-89	Strontium-90
Antioch	0.05	2.18	[illegible]	0.3	0.1	0.0	0.0	0.3
Berkeley	.02	.60	.5	.3	.1	.3	.0	.3
Eureka	.02	.78	.1	.4	.0	.1	.0	.2
Marin Municipal Water District	.02	2.11	.3	.6	.2	.0	.0	.4
Metropolitan Water District of Southern California	.09	3.00	.1	.5	.3	.2	.0	.9
Sacramento	.02	1.12	.2	.3	.3	.2	.0	.3
San Diego	.09	4.67	.4	.4	.4	.3	.0	1.8
San Francisco	.02	.52	.2	.1	.2	.4	.0	.5

tic water except that alpha analyses are also included. The sludge samples are dried and ashed. The ashed residue is counted for alpha and beta radioactivities in a gas-flow proportional counter.

Results and discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface and well water supplies in California for January-December 1970. Those water supplies listed in table 1 that have a potential for becoming contaminated with radioactive material either from sewage discharges or industrial effluents are: Antioch, sewage; El Centro, industrial; Los Angeles (20 percent), industrial; Metropolitan Water District of Southern California, industrial; and San Diego, industrial. The source of water for the last four (all except Antioch) is the Colorado River.

Table 2 shows the isotopic analyses of the 1970 yearly composites. Essentially, all the radionuclides originating from fallout were below detectable limits, except for strontium-90.

Table 3 presents the 1970 yearly average for alpha and beta radioactivity for sewage effluents and digested sludges. It is important to note that two values of effluent beta radioactivity were equal to or greater than the maximum permissible concentration that may be discharged to the uncontrolled environment (100 pCi/liter). Industries that contribute to both systems have been advised of the situation. El Centro has the highest alpha concentration in the effluent. If the Colorado River is the source of this high alpha concentration, then further analyses of the alpha radioactivity in domestic waters taken from the Colorado River should be made because this water is used extensively in Southern California.

Table 4 is a comparison of domestic water and sewage effluent. One would expect the sewage and domestic water of a town to have the same radioactivity. Where it is not the same, it is a measure of the disposal of radioactive wastes into the sewer system. Both the differences and ratios of beta concentrations are shown. Comparing either the sewage-water ratio or the difference, one can readily determine where vigilance of waste disposal practices into sewers is necessary.

Table 3. Gross radioactivity in California sewage samples 1970

Sewage treatment plant	Effluent (pCi/liter)		Sludge (pCi/g)	
	Alpha	Beta	Alpha	Beta
Antioch	1	14	7	26
Bakersfield	2	11	NS	NS
El Centro	15	19	24	30
Eureka	3	17	3	21
Fresno	4	22	20	33
Livermore	1	108	29	261
Los Angeles City	3	25	9	30
Los Angeles County	2	20	8	11
Oakland	1	35	11	30
Orange County No. 1	3	100	13	39
Orange County No. 2	3	36	35	71
Pleasanton	5	23	52	218
Sacramento	1	12	15	24
Salinas	6	15	29	32
San Diego	3	21	NS	NS
San Francisco:				
North Point	2	19	7	16
Richmond Sunset	1	6	7	33
Southeast	2	18	8	23
San Jose	0	39	NS	NS
Vallejo	5	13	9	[illegible]

NS, no sample.

Table 4. Comparison of radioactivity in California domestic water and sewage, 1970

Sampling station	Concentration (pCi/liter)			Ratio
	Water	Sewage	Difference	Sewage/water
Antioch	7	14	7	2.0
Berkeley	4	35	31	8.8
El Centro	20	20	0	1.0
Eureka	7	17	10	2.4
Livermore	8	108	100	13.5
Los Angeles	17	25	8	1.5
Pleasanton	4	23	19	5.8
Sacramento	5	12	7	2.4
San Diego	20	21	1	1.0
San Francisco, North Point	7	19	12	2.7
San Francisco, Richmond Sunset	7	7	0	1.0
San Francisco, Southeast	7	18	11	2.6

REFERENCE

(1) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analysis of environmental samples, a laboratory manual of methodology, Technical Report R59-6. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (Revised February 1966).

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January-December 1969	October 1971

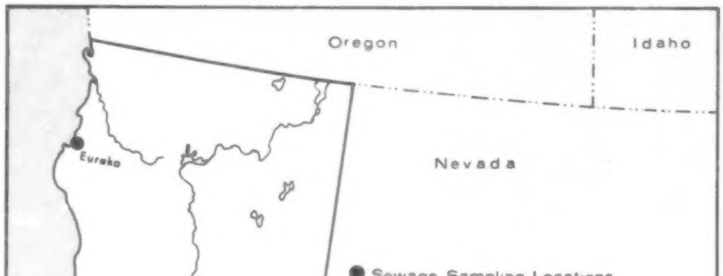
Oregon
Idaho
Nevada
Eureka
Sewage Sampling Locations
Vallejo
Sacramento
Antioch
San Francisco
North Point
Richmond Sunset
Southeast
Pleasanton
Livermore
East Bay Municipal Utility District
San Jose
Salinas
Fresno
0 20 40 60 Miles
0 20 40 60 km
N
Bakersfield
PACIFIC
OCEAN
Los Angeles, City
Los Angeles, County
Orange County, Plant 1
Orange County, Plant 2
Ariz.
San Diego
El Centro
Mexico

Figure 2. California Sewage Network

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican Air Monitoring Program	February-December 1971	May 1972
Plutonium in Airborne Particulates	July-September 1971	April 1972
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January-December 1969	February 1972

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1. Radiation Alert Network
February 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, North Carolina 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during February 1972.

All field estimates reported were within normal limits for the reporting station.

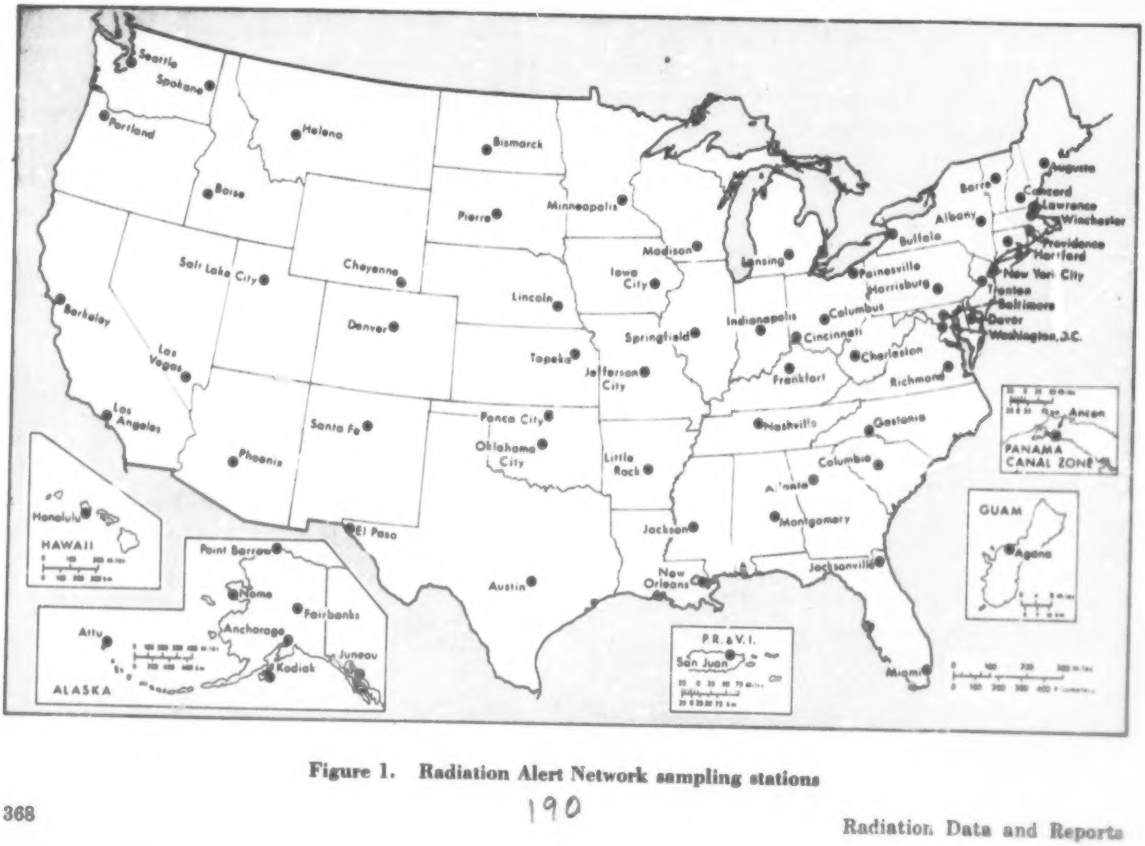
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Minneapolis
Pierre
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Las Vegas
Topeka
Jefferson City
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
Honolulu
HAWAII
El Paso
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
Austin
Jackson
New Orleans
P.R. & V.I.
San Juan
Miami
Jacksonville
Montgomery
Atlanta
Columbia
Gastonia
Nashville
Frankfort
Richmond
Charleston
Cincinnati
Springfield
Indianapolis
Columbus
Iowa City
Madison
Lansing
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1972

Station location		Gross beta radioactivity (5-hour field estimate) (pCi/m³)				Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
		Number of samples	Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	2	0	1	3	62	3	62	7
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	29	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	12	11	1	5	0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	16	1	0	0	4	36	4	36	0
	Los Angeles	20	4	1	2	0				
C.Z:	Ancon	16	0	0	0	0		(b)		
Colo:	Denver	20	5	0	2	9	90	9	90	0
Conn:	Hartford	19	0	0	0	0				
Del:	Dover	19	0	0	0	0				
D.C:	Washington	12	0	0	0	0				
Fla:	Jacksonville	20	1	0	0	8	97	7	90	12
	Miami	14	1	0	0	5	76	5	76	0
Ga:	Atlanta	21	2	1	1	1	254	1	254	13
Guam:	Agana	0				0				
Hawaii:	Honolulu	20	1	0	0	5	96	(b)		
Idaho:	Boise	1	0	0	0	0				
Ill:	Springfield	17	3	0	1	0				
Ind:	Indianapolis	20	1	0	0	0				
Iowa:	Iowa City	19	1	0	0	6	39	6	39	1
Kans:	Topeka	21	6	0	2	1	3	1	3	2
Ky:	Frankfort	0				0				
La:	New Orleans	16	0	0	0	7	134	(b)		
Maine:	Augusta	18	0	0	0	3	49	3	49	0
Md:	Baltimore	19	2	0	0	6	58	6	58	0
Mass:	Lawrence	20	0	0	0	6	83	6	83	0
	Winchester	18	1	0	0	7	124	7	124	0
Mich:	Lansing	21	0	0	0	0				
Minn:	Minneapolis	20	0	0	0	0				
Miss:	Jackson	19	1	0	0	4	117	3	62	0
Mo:	Jefferson City	19	2	0	1	3	10	3	10	0
Mont:	Helena	15	1	0	0	2	13	2	13	0
Nebr:	Lincoln	13	5	0	1	1	5	1	5	0
Nev:	Las Vegas	19	3	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	9	113	9	113	2
N. Mex:	Santa Fe	16	2	0	1	0				
N.Y:	Albany	17	0	0	0	0				
	Buffalo	16	0	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	6	0	2	5	25	(b)		
N. Dak:	Bismarck	20	0	0	0	6	17	6	17	3
Ohio:	Cincinnati	0				0				
	Columbus	3	0	0	0	0				
	Painesville	20	0	0	0	7	47	7	47	7
Okla:	Oklahoma City	9	3	1	1	0				
	Ponca City	20	4	1	2	2	12	2	12	0
Oreg:	Portland	18	1	0	0	13	166	13	166	2
Pa:	Harrisburg	14	1	0	0	0				
P.R:	San Juan	2	6	1	3	0				
R.I:	Providence	19	1	0	0	0				
S.C:	Columbia	14	2	0	0	3	63	3	63	0
S. Dak:	Pierre	20	2	0	1	0				
Tenn:	Nashville	19	1	0	0	9	88	9	88	3
Tex:	Austin	15	7	0	2	1	5	(b)		
	El Paso	7	6	0	2	0				
Utah:	Salt Lake City	29	3	0	1	2	4	2	4	2
Vt:	Barre	17	1	0	0	6	61	6	61	6
Va:	Richmond	19	0	0	0	3	45	3	45	11
Wash:	Seattle	8	0	0	0	1	18	(b)		
	Spokane	17	0	0	0	0				
W. Va:	Charleston	21	2	0	0	11	126	11	126	14
Wisc:	Madison	20	0	0	0	7	17	7	17	2
Wyo:	Cheyenne	20	4	0	1	0				
Network summary		993	11	0	1	166	77	5	65	3

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[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program, February 1972 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussion of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for February 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	6	0.1	0.0	0.1	75	1.6
Coral Harbour	5	.1	.0	.1	76	.4
Edmonton	5	.1	.1	.1	11	.5
Ft. Churchill	5	.1	.0	.1	40	.3
Fredericton	5	.1	.0	.1	15	1.4
Goose Bay	5	.1	.0	.1	32	1.5
Halifax	5	.1	.1	.1	17	2.3
Inuvik	3	.1	.0	.0	62	.7
Montreal	5	.1	.0	.0	4	.3
Moosonee	5	.1	.1	.1	54	.6
Ottawa	5	.1	.0	.1	10	1.4
Quebec	5	.1	.0	.1	15	1.1
Regina	5	.1	.0	.1	19	.6
Resolute	5	.1	.0	.1	77	.3
St. John's, Nfld	5	.1	.0	.0	15	1.9
Saskatoon	5	.1	.1	.1	21	.4
Sault Ste. Marie	NS				15	1.2
Thunder Bay	5	.1	.1	.1	26	.6
Toronto	5	.1	.0	.0	22	1.7
Vancouver	5	.0	.0	.0	23	3.1
Whitehorse	5	.1	.1	.1	33	.8
Windsor	7	.1	.0	.0	34	1.2
Winnipeg	5	.1	.0	.1	44	.5
Yellowknife	4	.1	.1	.1	42	.5
Network summary	115	0.1	0.0	0.1	33	1.0

NS, no sample av. .able.

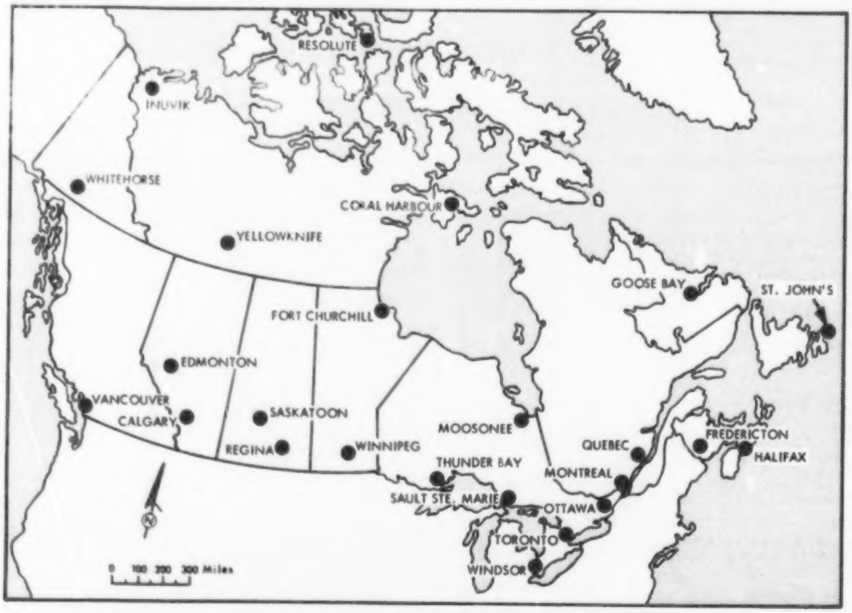
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program
February 1972

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The February 1972 air monitoring results from the participating countries are given in table 3.

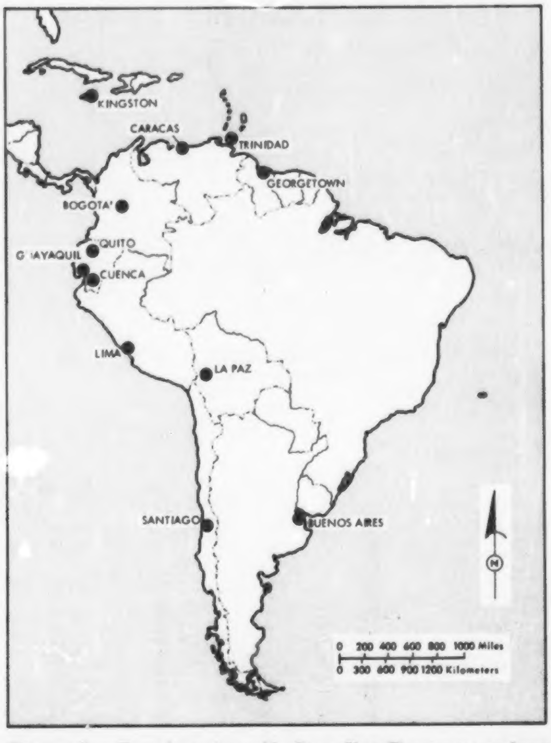

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	8	0.11	0.07	0.09
Colombia:	Bogota	21	.07	.00	.02
Ecuador:	Cuenca	0			
	Guayaquil	7	.10	.02	.07
	Quito	4	.00	.00	.00
Guyana:	Georgetown	3	.01	.01	.01
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	14	.03	.00	.01
West Indies:	Trinidad	0			
Pan American summary		57	0.11	0.00	0.03

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program
February 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a contin-

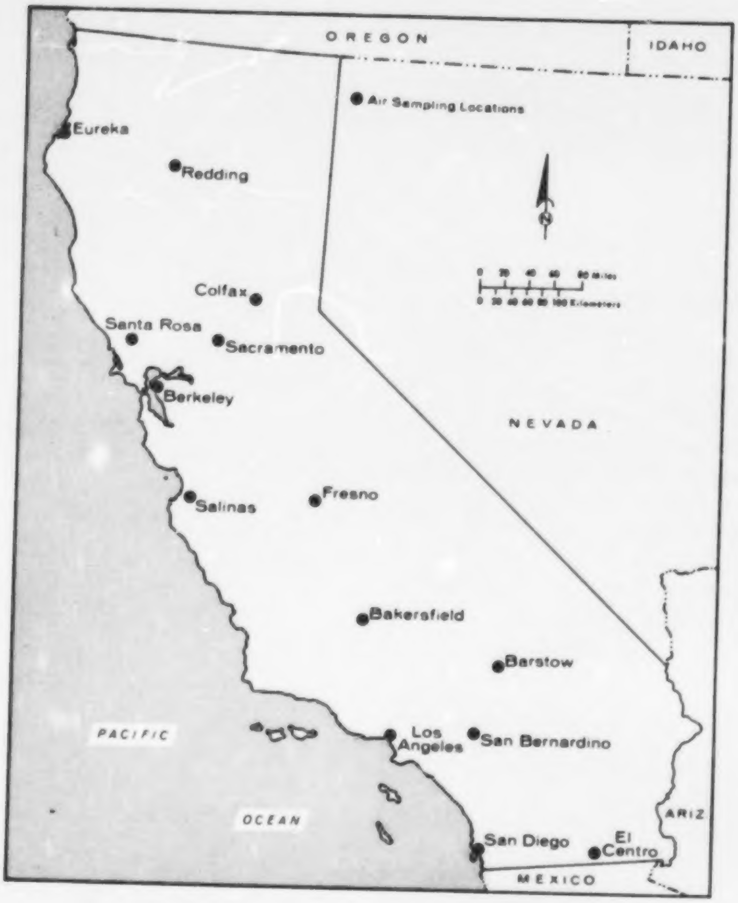
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
OCEAN
Los Angeles
San Bernardino
San Diego
El Centro
ARIZ
MEXICO
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers

Figure 4. California Air Sampling Program stations

uous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct-reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for February 1972.

Table 4. Gross beta radioactivity in California air February 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	29	1.12	0.10	0.39
Barstow	29	1.13	.17	.40
Berkeley	29	.54	[illegible]	[illegible]
Colfax	27	.49	.00	.17
El Centro	29	1.90	.18	.40
Eureka	29	.52	.01	.10
Fresno	29	1.03	.08	.25
Los Angeles	29	.80	.00	.27
Redding	29	.51	.00	.16
Sacramento	27	.57	.05	.18
Salinas	23	1.44	.05	.36
San Bernardino	28	.99	.09	.33
San Diego	29	.61	.06	.23
Santa Rosa	29	.55	.04	.16
Summary	395	1.90	0.00	0.25

194

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Air Surveillance Network, February 1972[1]

Western Environmental Research Laboratory
Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the Western Environmental Research Laboratory (WERL), Las Vegas, Nev., consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station which lies within the NTS, and by the AEC at any other designated testing sites.[1]

The stations are operated by State health department personnel and by private individuals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates for each of the network stations. The minimum reported concentration for gross beta radioactivity is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reported level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3.

No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges collected during February 1972.

Copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the WERL upon written request.

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[1] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

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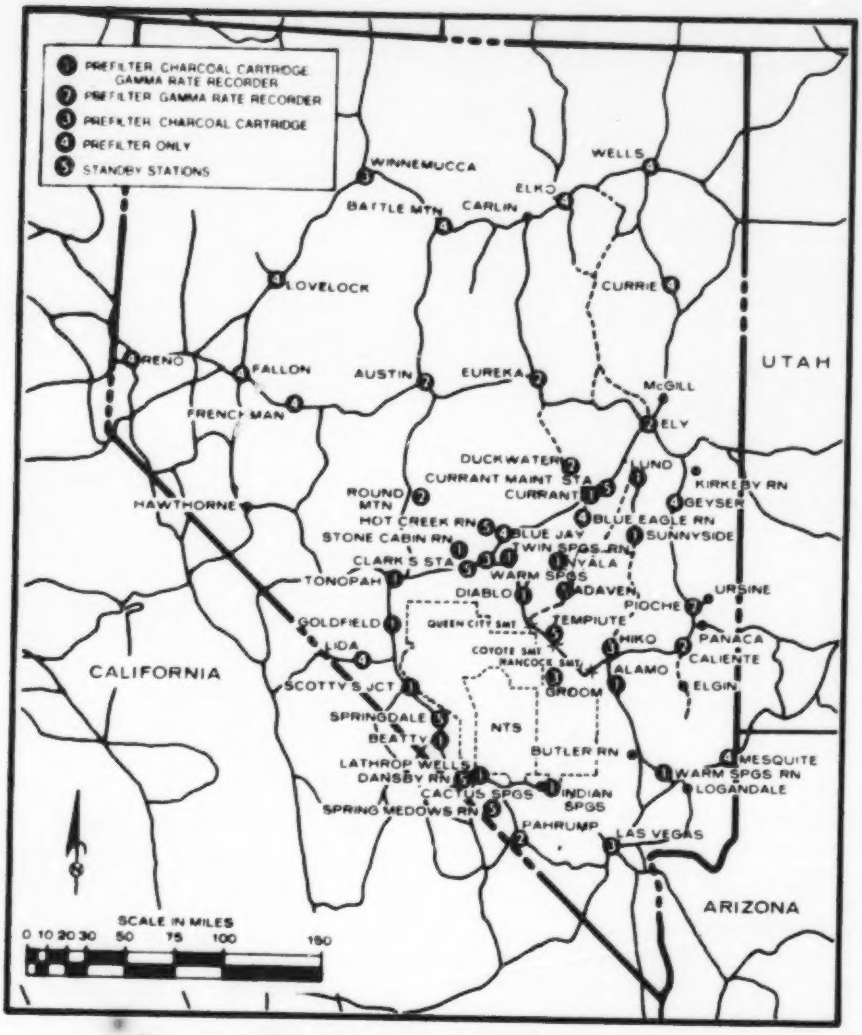
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③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
WINNEMUCCA
WELLS
ELKO
BATTLE MTN
CARLIN
LOVELOCK
CURRIE
UTAH
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT STA
CURRANT
KIRKEBY RN
ROUND MTN
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE EAGLE RN
STONE CABIN RN
BLUE JAY
SUNNYSIDE
TWIN SPGS RN
CLARK'S STA
NYALA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
URSINE
PIOCHE
GOLDFIELD
QUEEN CITY SMT
TEMPIUTE
HIKO
PANACA
LIDA
COYOTE SMT
HANCOCK SMT
CALIENTE
CALIFORNIA
ALAMO
SCOTTY'S JCT
GROOM
ELGIN
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
INDIAN SPGS
LOGANDALE
CACTUS SPGS
SPRING MEDOWS RN
PAHRUMP
LAS VEGAS
ARIZONA
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. WERL Air Surveillance Network stations in Nevada

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Table 1. Summary of gross beta radioactivity concentrations in air, February 1972

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average^a
Ariz:	Kingman	29	0.7	<0.1	0.2
	Phoenix	25	.6	<.1	.2
	Seligman	24	.6	<.1	.2
	Winslow	29	.5	<.1	.2
Ark:	Little Rock	15	.3	<.1	.1
Calif:	Baker	27	.5	.1	.2
	Barstow	29	.7	<.1	.2
	Bishop	29	.5	<.1	.2
	Death Valley Junction	30	.5	<.1	.2
	Furnace Creek	28	.6	.1	.2
	Indio	29	.6	<.1	.2
	Lone Pine	25	.5	<.1	.2
	Needles	25	.5	.1	.2
	Ridgecrest	29	.6	<.1	.2
	Shoshone	29	.6	.1	.2
Colo:	Denver	20	.3	<.1	.1
	Durango	28	1.1	<.1	.2
Idaho:	Boise	29	.4	<.1	.2
	Idaho Falls	18	.3	<.1	.1
	Preston	29	.3	<.1	.1
	Twin Falls	28	.3	<.1	.1
Iowa:	Iowa City	19	.3	.1	.1
	Sioux City	25	.2	<.1	.1
Kans:	Dodge City	29	.3	.1	.1
La:	Lake Charles	19	.3	<.1	.1
	Monroe	15	.2	.1	.1
	New Orleans	16	.3	<.1	.1
Minn:	Minneapolis	20	.2	.1	.1
Mo:	Joplin	29	.3	<.1	.1
	St. Joseph	29	.2	<.1	.1
	St. Louis	28	.2	<.1	.1
Nebr:	North Platte	24	.3	<.1	.1
Nev:	Alamo	29	.4	<.1	.2
	Austin	20	.4	.1	.1
	Battle Mountain	29	.4	<.1	.2
	Beatty	28	.5	.1	.2
	Blue Eagle Ranch (Current)	9	.4	.1	.2
	Blue Jay	28	.5	<.1	.1
	Caliente	29	.4	.1	.2
	Currant Ranch	28	.5	<.1	.2
	Currie	29	.4	<.1	.1
	Diablo	29	.6	<.1	.2
	Duckwater	24	.5	<.1	.1
	Elko	28	.3	<.1	.2
	Ely	27	.5	<.1	.1
	Eureka	29	.4	<.1	.2
	Fallini's Twin Springs Ranch	29	.4	<.1	.1
	Fallon	29	.4	<.1	.1
	Frenchman Station	29	.4	<.1	.1
	Geyser Maintenance Station	15	.2	<.1	.1
	Goldfield	28	.5	<.1	.1
	Groom Lake	29	.5	<.1	.2
	Hiko	29	.5	<.1	.2
	Indian Springs	29	.5	<.1	.1
	Las Vegas	20	.5	.1	.2
	Lathrop Wells	26	.5	.1	.2
	Lida	29	.4	<.1	.2
	Lovelock	29	.5	<.1	.2
	Lund	28	.5	<.1	.2
	Mesquite	29	.4	<.1	.2
	Nyala	29	.5	<.1	.2
	Pahrump	21	.4	.1	.1
	Pioche	27	.3	<.1	.1
	Reno	29	.3	<.1	.1
	Round Mountain	26	.5	<.1	.1
	Scotty's Junction	28	.6	<.1	.2
	Stone Cabin Ranch	29	.5	<.1	.2
	Sunnyside	27	.4	.1	.1
	Tonopah	29	.5	<.1	.1
	Tonopah Test Range	25	.4	.1	.1
	Warm Springs Ranch	29	.4	<.1	.1
	Wells	29	.4	<.1	.1
	Winnemucca	29	.4	<.1	.1
N. Mex:	Albuquerque	19	.3	<.1	.1
	Carlsbad	27	.8	<.1	.2
Okla:	Muskogee	29	.4	.1	.1
Oreg:	Burns	29	.4	<.1	.1
	Medford	25	.4	<.1	.1
S. Dak:	Aberdeen	29	.2	<.1	.1
	Rapid City	29	.2	<.1	.1
Tex:	Abilene	27	.5	.1	.2
	Amarillo	29	.8	<.1	.1
	Austin	14	.3	.1	.1
	Fort Worth	15	.3	<.1	.2
Utah:	Bryce Canyon	20	.2	<.1	.1
	Cedar City	27	.4	<.1	.1
	Delta	28	.3	<.1	.1

See footnote at end of table.

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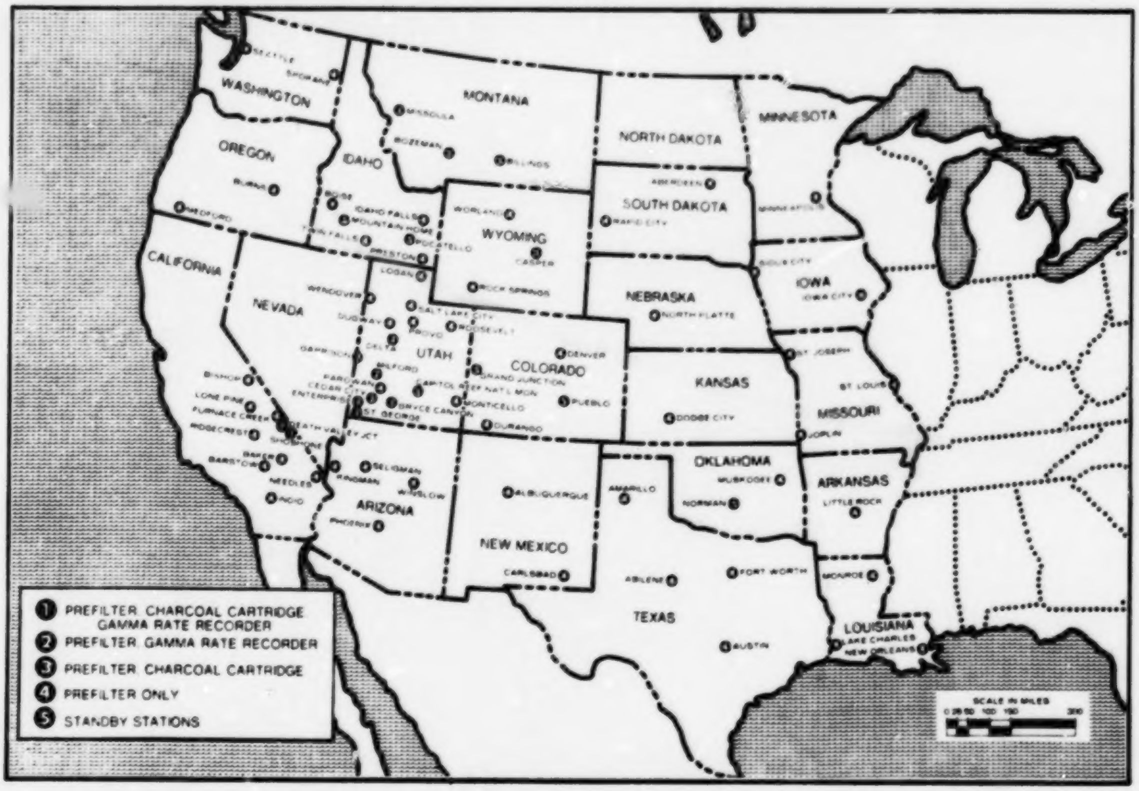
Table 1. Summary of gross beta radioactivity concentrations in air, February 1972 —continued

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average[a]
	Dugway	29	.4	<.1	.1
	Enterprise	29	.3	.1	.2
	Garrison	29	.3	<.1	.1
	Logan	29	.3	<.1	.1
	Milford	29	.4	<.1	.1
	Monticello	16	.5	<.1	.2
	Parowan	29	.3	<.1	.1
	Provo	28	.9	<.1	.2
	Roosevelt	29	.4	<.1	.1
	Salt Lake City	29	.3	<.1	.1
	St. George	29	.4	<.1	.2
	Wendover	28	.3	<.1	.2
Wash:	Seattle	20	.3	<.1	.1
	Spokane	15	.2	<.1	.1
Wyo:	Rock Springs	28	.4	<.1	.1
	Worland	28	.4	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reported value of 0.1 pCi/m^3 is reported as <0.1.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SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNESOTA
MINNEAPOLIS
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
CALIFORNIA
NEVADA
UTAH
LOGAN
WENDOVER
SALT LAKE CITY
DUGWAY
PROVO
ROOSEVELT
DELTA
GARRISON
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST. GEORGE
BRYCE CANYON
CAPITOL REEF NAT'L MON
MONTICELLO
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
KANSAS
DODGE CITY
MISSOURI
ST JOSEPH
ST LOUIS
JOPLIN
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
DEATH VALLEY JCT
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
ARIZONA
SELIGMAN
KINGMAN
WINSLOW
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
OKLAHOMA
MUSKOGEE
NORMAN
AMARILLO
ARKANSAS
LITTLE ROCK
TEXAS
ABILENE
FORT WORTH
AUSTIN
LOUISIANA
MONROE
LAKE CHARLES
NEW ORLEANS
SCALE IN MILES
0 25 50 100 150 200
① PREFILTER, CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER, GAMMA RATE RECORDER
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④ PREFILTER ONLY
⑤ STANDBY STATIONS

Figure 2. WERL Air Surveillance Network Stations outside Nevada

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site July-December 1967[1]

*Western Environmental Research Laboratory,[2]
EPA, and Nevada Operations Office, AEC*

Under a Memorandum of Understanding with the U.S. Atomic Energy Commission (AEC), the Southwestern Radiological Health Laboratory (SWRHL) conducted its continuing program of radiological surveillance, including monitoring and environmental sampling, in the public areas surrounding the Nevada Test Site (NTS) from July through December 1967. During this period, 11 announced underground nuclear tests were conducted at the NTS and three Experimental Plans of the NRX-A6 reactor test series were conducted at the Nuclear Rocket Development Station (NRDS), a part of the NTS complex. Offsite radiological surveillance also was provided for the twelfth announced test, Project Gasbuggy, an underground gas-stimulation project conducted in New Mexico on December 10, 1967.

Operational procedures

Before each event, mobile ground monitors were positioned downwind. If a release occurred, they conducted a monitoring program directed from the AEC control point. In addition to the routine sampling and monitoring provided within 300 miles of each nuclear event, surveillance was extended as necessary to provide adequate coverage. Measurements were made periodically until radioactivity levels returned to background.

Each monitor was equipped with two Eberline E-500B survey meters, a Baird-Atomic NE-148A Scintillator, a Victoreen Radector, Model No. AGB-50B-Sr, and a Precision Model III Standard Scintillator. Eberline RM-11 gamma-rate recorders at fixed locations documented cloud passage. An Air Force U-3A aircraft was used for aerial cloud tracking and two SWRHL Turbo-Beech aircraft provided additional long-range tracking and sampling.

The SWRHL Air Surveillance Network (ASN) consisted of 105 stations operating in every State west of the Mississippi River except Montana and North Dakota (figure 1). The air sampler used in the ASN was a Gelman "Tempest," consisting of a Gast Model 1550 vacuum pump driven by a ½ horsepower motor. The filter media used was a 4-inch-diameter Whatman 541 filter paper and an MSA charcoal cartridge.

The established milk sampling program from both commercial and private producers continued through the 6-month period. A total of 202 samples was collected from 36 locations.

Vegetation samples were collected after known releases of radioactivity to help delineate the fallout pattern. Samples of both potable and nonpotable water were collected from about 90 locations.

Approximately 153 residents in the offsite

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[1] This article is a summary of report No. SWRHL-64r, "Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from July through December 1967."

[2] Formerly the Southwestern Radiological Health Laboratory of the U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Control Administration, Bureau of Radiological Health.

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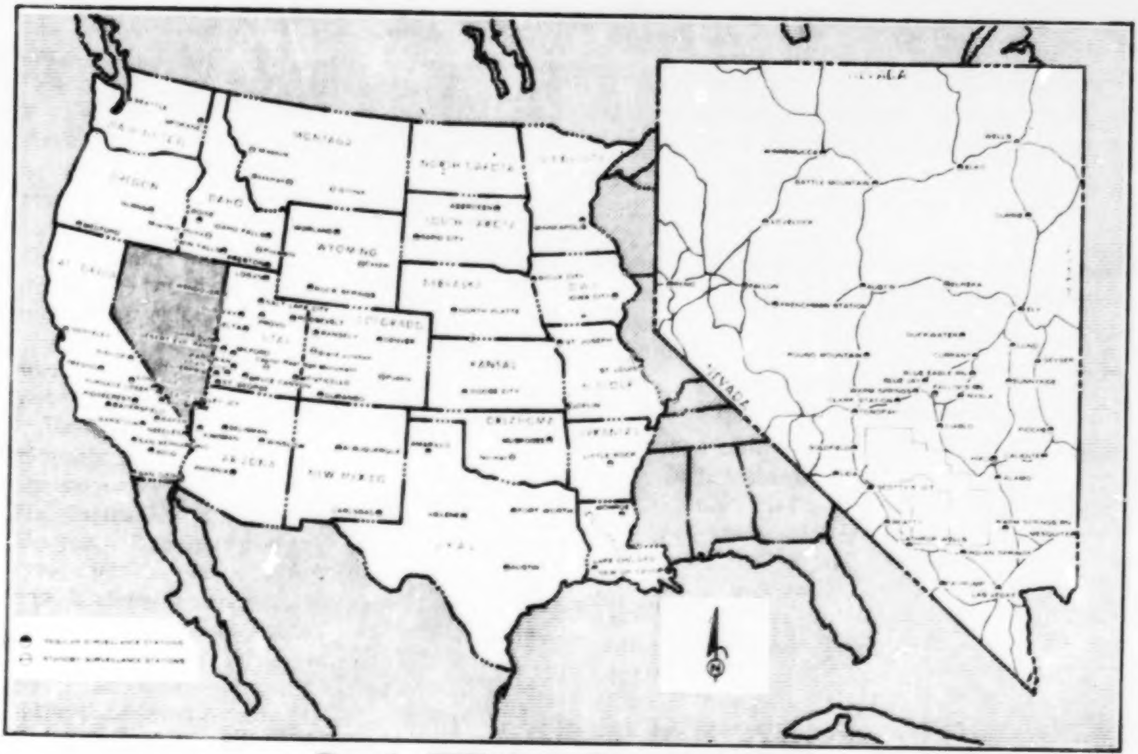

Figure 1. WERL air surveillance network stations

area wore film badges. Five film badges were placed at each of 95 dosimetry stations, 86 of which also were equipped with three EG&G model TL-12 thermoluminescent dosimeters (TLD). The film badge used contained DuPont type 545 film and has a 30 mR lower limit of detection.

A SWRHL medical officer was available to investigate reports of personal injuries alleged to be a result of the test series and to maintain liaison with local physicians. No injuries were reported. Veterinarian services also were provided by the SWRHL to conduct wildlife and domestic livestock investigations.

Analytical procedures

Samples were returned to the SWRHL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman Widebeta, low background, proportional counter system. Selected particulate filters, all charcoal cartridges, and water and milk samples were analyzed for gamma-emitting isotopes; a 4-by 4-inch NaI(Tl) crystal coupled to a TMC Model 404C gamma pulse height analyzer was used. The lower limit of detection for gamma emitters in milk samples was 20 pCi/liter at the time of count. Gamma spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides (^{40}K, ^{99}Mo, ^{131}I, ^{132}Te, ^{133}I, ^{135}I, ^{137}Cs, and ^{141}Ce).

Results

Radioactive material was released offsite following one underground nuclear test, the Door Mist Event. Project Gasbuggy, the Plowshare gas stimulation experiment conducted in New Mexico, did not release any radioactivity. One power operation of the NRX-A6 reactor test series, EP IIIA, December 15, released radioactive material which was detected offsite (tables 1, 2, and 3).

Table 1. Highest 13 readings of radiation survey instrument—NRX-A6, EP IIIA, December 15, 1967

Location in Nevada	Azimuth and distance from test cell C		Time period monitored (hours)	Cloud arrival time	GM survey meter readings (maximum net gamma)		Gamma exposure (mR)
	Degree	Distance (miles)			(mR/h)	Time	
8.1 miles west of Lathrop Wells, Highway 95	235	18.0	1200–1555	1210	0.8	1234	2.0
From 16.5 miles west of Lathrop Wells on Highway 95 to Lathrop Wells			1150–1252		[a].8	1234	
Danby Ranch, Lathrop Wells	221	23.5	1110–1510	1240	1.1	1253	.71
Seibach Strickland Ranch, Lathrop Wells	222	24.0	1055–1240	1240	1.0	1257	1.3
Hord Ranch, Lathrop Wells	223	23.5	1125–1600	1240	.9	1252	.82
Rich (Davis) Ranch, Lathrop Wells	214	23.5	1135–1350	1200	.9	1255	.32
Nickell Ranch, Lathrop Wells	222	23.5	1100–1545	1230	1.0	1251	.59
Corder Ranch, Lathrop Wells	223	23.5	1115–1420	1240	1.5	1251	1.1
Oswald Ranch, Lathrop Wells	223	24.0	1130–1510	1235	1.0	1252	.95
Allison Ranch, Lathrop Wells	222	24.0	1130–1515	1230	1.0	1252	.64
Nicholl residence, Lathrop Wells	220	23.0	1000–1500	1240	.8	1251	.76
Schultz Farm, Lathrop Wells	227	23.5	1115–1500	1230	.8	1254–1258	1.1
McCarthy-Caldell Ranch, Lathrop Wells	233	21.0	1128–1505	1230	[b].6	1256	1.8

[a] Readings were taken every few miles, the highest (0.8 mR/h) occurred at 3.9 miles west of Lathrop Wells.
[b] There were several higher exposure rates; however, this represented the highest estimated exposure at a populated location.

Table 2. Highest air results in off-NTS areas, July-December 1967 (NRX-A6, EP IIIA)

Location, azimuth and distance from test cell C	Date and time on	Date and time off	Collector[a]	Gross beta concentration		Iodine-131 concentration	
				(pCi/m³)	(μCi-sec/m³)	(pCi/m³)	(μCi-sec/m³)
Death Valley Junction, Calif.; 191°; 38 miles	12/15 0630	12/16 0730	PF CC	8.8	0.75	1.9 2.2	0.17 .20
Furnace Creek, Calif.; 233°; 58 miles	12/15 1430	12/16 1230	PF CC	1.8	.14	.7 1.5	.055 .12
Hord Ranch, Amargosa Farm area, Lathrop Wells, Nev.; 223°; 23.5 miles	12/15 1115	12/15 1610	PF CC	460	6.1	9.0 ND	.16 ND
Junction Highways 395 and 14 near Inyokern, Calif.; 229°; 120 miles	12/15 1615	12/16 1435	PF CC	2.6	.21	.8 1.3	.064 .10
Nickell Ranch, Amargosa Farm area, Lathrop Wells, Nev.; 222°; 23.5 miles	12/15 1115	12/15 1600	PF CC	300	5.2	7.2 ND	.12 ND
7.5 miles west Lathrop Wells, Nev.; Highway 95; 233°; 17 miles	12/15 1155	12/15 1620	PF CC	57	.92	4.2 ND	.068 ND

[a] PF, particulate filter; CC, charcoal cartridge.
ND, not detected.

Table 3. The six highest concentrations of iodine-131 in milk in off-NTS areas, July-December 1967 (NRX-A6, EP IIIA)

Location in Nevada	Date milked	Peak radionuclide concentration (pCi/liter)			
		Iodine-131	Iodine-133	Strontium-89	Strontium-90
Lathrop Wells, Danby's Ranch	12/16	90	400	<5	2
Lathrop Wells, Rooker Ranch	12/18	90	70	<5	3
Lathrop Wells, Hord Ranch	12/18	80	50	<5	<1
Lathrop Wells, Danby's Ranch	12/18	70	80	6	<1
Lathrop Wells, Rooker Ranch	12/19	70	20	<5	3
Lathrop Wells, Rooker Ranch	12/21	70	<20	<5	2

The highest level of radioactivity attributable to the Door Mist Event was about 0.01 mR/h above background measured at Diablo, Nev., by ground monitors. The air sample from Diablo, which contained several pCi/m³ of iodine-133 and iodine-135, was the only ground level environmental sample which contained radioactivity related to this event. None of the five special milk samples nor the 43 vegetation samples collected from offsite locations following the event showed the presence of fresh fission products. Film badges and TLD's collected following the test date showed no exposures that could be attributed to the Door Mist Event.

A peak offsite reading of 18 mR/h was ob-

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tained by an aerial surveillance team at an altitude of 8,500 feet about 28 miles from the site of the EP IIIA of the NRX-A nuclear rocket reactor. Particles reading greater than 200 mR/h beta gamma on portable GM survey instruments were found in maximum deposition density of 0.2 particles/m^2 just beyond Highway 190. However, all levels of external radiation measured by ground monitors at 3 feet above the surface were relatively low, the highest being 0.3, 0.8, and 1.5 mR/h above background recorded, respectively, at Lathrop Wells, at points along Highway 95, and at residences in the Amargosa Valley.

Of the 79 water samples collected following EP IIIA, none taken from water used for human consumption showed detectable amounts of fresh fission products. No TLD or film badge worn by ground personnel or distributed along the routine dosimetry network indicated exposures above background. Of the 106 milk samples collected, 21 contained radioactivity which was measured in maximum concentrations of 90 pCi/liter of iodine-131 and 400 pCi/liter of iodine-133. These were collected near Lathrop Wells. The highest concentrations of iodine-131 in milk collected in California was 20 pCi/liter collected near Olancha. The predominant source of radioactivity measured offsite during this period was the NRX-A6, EP IIIA.

Conclusions

Environmental radiation surveillance during this period indicates that no individual in the offsite area received an exposure resulting from nuclear testing activities in Nevada which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.[1] The maximum estimated thyroid dose for a hypothetical child with a 2-gram thyroid was about 10 mrad.

REFERENCE

(*1*) U.S. ATOMIC ENERGY COMMISSION. U.S. Atomic Energy Commission Rules and Regulations, Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation.

Environmental Levels of Radioactivity At Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactivity materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follow for the Brookhaven National Laboratory.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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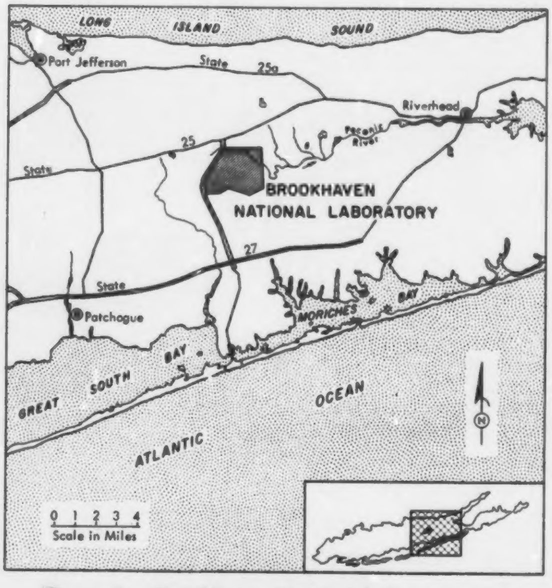
1. Brookhaven National Laboratory [2]
January–June 1968

Associated Universities, Inc.
Upton, N.Y.

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by radioactivity in the cooling air from the research reactors, (2) by radiation from an ecology forest gamma-ray source, and (3) by low-level radioactive liquid wastes released to a stream that forms one of the headwaters of the Peconic River (figure 1). The radiation levels resulting from reactor air effluent and the ecology forest source are monitored continuously by four stations located at the site boundary. The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the site.

Area monitoring

The average weekly radiation levels at the Brookhaven National Laboratory site perimeter (figure 2), due to laboratory operations, are given in table 1. Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to a cesium-137 source located in the nearby forest. However, the radiation levels at this location were only 17 percent of the applicable upper limit of the AEC radiation protection standard (500 mrem/a) for individuals in the general population. Values of radiation background levels undisturbed by laboratory operations also have been included in table 1 for purposes of comparison.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27
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GREAT SOUTH BAY
ATLANTIC OCEAN
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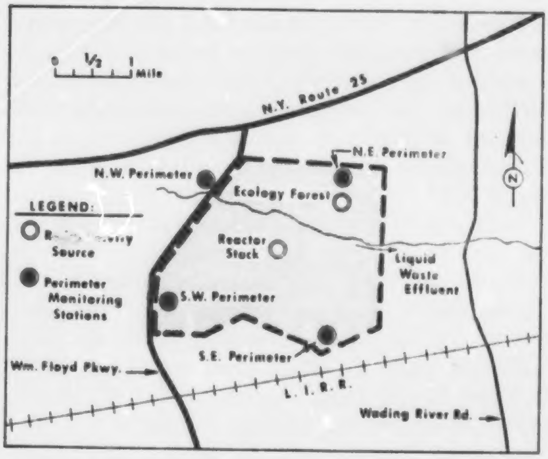
Scale in Miles

Figure 1. Brookhaven National Laboratory and surrounding area


0 1/2 1 Mile
N.Y. Route 25
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Ecology Forest
LEGEND:
Radioactivity Source
Perimeter Monitoring Stations
Reactor Stack
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S.W. Perimeter
S.E. Perimeter
Wm. Floyd Pkwy.
L. I. R. R.
Wading River Rd.
N

Figure 2. Brookhaven National Laboratory monitoring station locations

Table 1. External gamma radioactivity at BNL site perimeter due to laboratory operations,[a] January-June 1968

Date (1968)	Average exposure rates (mR/week)			
	North-west perim-eter	South-west perim-eter	South-east perim-eter	North-east perim-eter
January	0.05	0.06	0.35	1.43
February	.1	.12	.34	1.27
March	.02	.11	.17	1.57
April	.23	.06	.09	1.77
May	.04	.15	.07	2.16
June	.10	.02	.15	2.24
January-June average	0.08	0.08	0.19	1.74
Highest weekly reading	0.49	0.46	1.36	3.50
Lowest weekly reading	0	0	0	.94
Average undisturbed background (January-June)	1.72	2.01	1.88	1.74

[a] Due principally to argon-41 in reactor cooling air and at the northeas perimeter, to the ecology forest cesium-137 source.

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[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the First Half of 1968," Associated Universities Inc., Upton, N.Y. 11973

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the BNL site. The average concentration and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for January-June 1968.

Analysis of composite samples of the effluent has shown that, on the average, less than 20 percent of the radioactivity consists of strontium-90. No appreciable amounts of radioactive iodine or bone-seeking radionuclides, (such as radium) other than strontium, were present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 1 nCi/liter.

The gross beta measurements do not include very low energy beta emitters, such as tritium, for which special analysis methods must be employed. The concentration and amount of tritium found during this reporting period in the laboratory's liquid waste effluent are also shown in table 2. The applicable AEC standard is 3 μCi/liter averaged over a period of 1 year.

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary, January-June 1968

Date (1968)	Average beta radioactivity concentration (pCi/liter)	Total beta radioactivity concentration discharged (mCi)	Tritium concentration (nCi/liter)	Tritium radioactivity (Ci)
January	21	1.6	14	1.0
February	17	1.2	18	.6
March	20	2.2	25	2.9
April	15	1.7	19	2.1
May	17	1.8	15	1.6
June	16	2.3	3	.4
January-June	18	10.8	14	8.5

Recent coverage in *Radiation Data and Reports*

Period	Issue
July-December 1967	May 1972

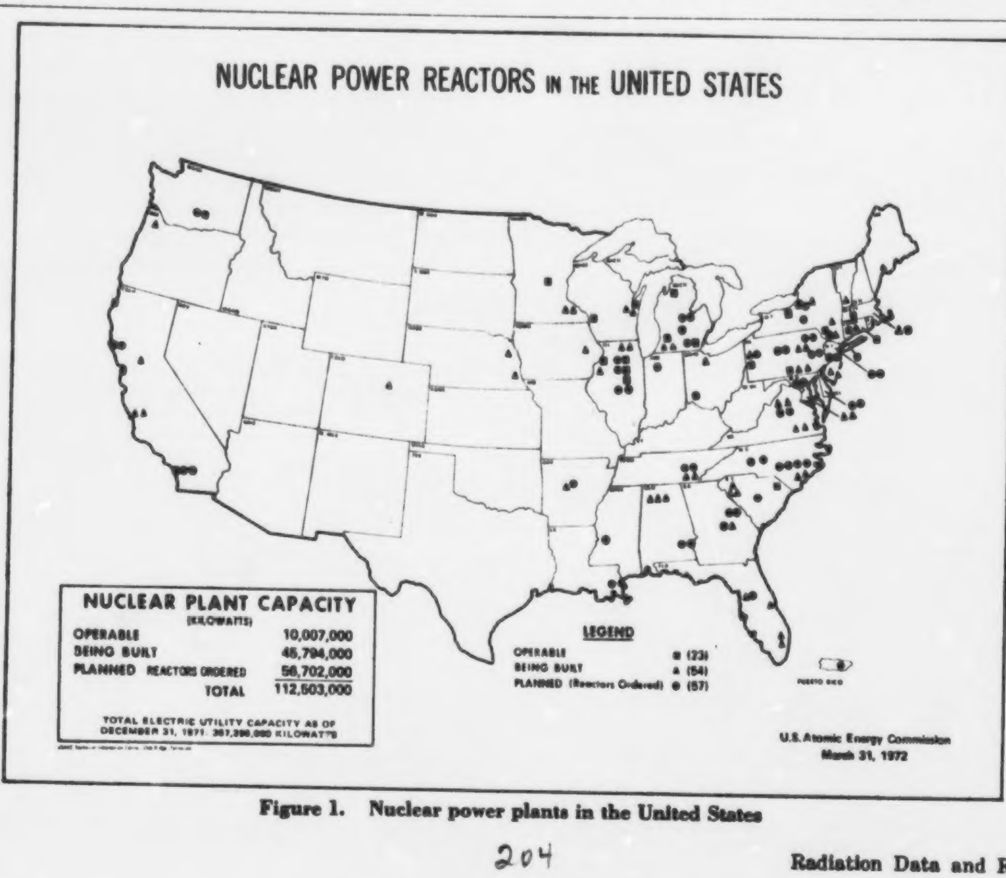
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 10,007,000
BEING BUILT 45,794,000
PLANNED REACTORS ORDERED 56,702,000
TOTAL 112,503,000
TOTAL ELECTRIC UTILITY CAPACITY AS OF DECEMBER 31, 1971: 367,396,000 KILOWATTS
LEGEND
OPERABLE ■ (23)
BEING BUILT ▲ (54)
PLANNED (Reactors Ordered) ● (57)
PUERTO RICO
U.S. Atomic Energy Commission
March 31, 1972

Figure 1. Nuclear power plants in the United States

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1976
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	920,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generation Station	804,000	Sacramento Municipal Utility District	1973
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1979
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
DELAWARE				
*	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1979
*	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Turkey Point	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Red Level	Crystal River Plant: Unit 4	897,000	Florida Power Corp.	1978
Ft. Pierce	Hutchinson Island: Unit 1	800,000	Florida Power and Light Co.	1974
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,100,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,100,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1977
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
*	Comed West: Unit 1	1,100,000	Comm. Edison Co.	1978
*	Comed West: Unit 2	1,100,000	Comm. Edison Co.	1979
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station	1,165,000	Louisiana Power & Light Co.	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
Perryman	Perryman Nuclear Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1979
Perryman	Perryman Nuclear Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1980
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	655,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,150,000	Boston Edison Co.	1978
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1975
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,123,000	Detroit Edison Co.	1979
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1977
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1978
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station	1,290,000	Mississippi Power & Light Co.	1978

Figure 1. Nuclear power plants in the United States—continued

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SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N. J.	1974
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N. J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N. J.	1978
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N. J.	1979
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1972
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Con. Ed. Nuclear #4	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N. Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1976
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1976
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.-Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	847,000	Duquesne Light Co.-Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1973
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
*	Philadelphia Electric Co. HTGR No. 1	1,140,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co. HTGR No. 2	1,140,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconne Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Broad River	Virgil C Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1975
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	Hanford No. 2	1,110,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Puerto De Jobos	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975

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* Site not selected.

*	–	1,175,000	Tennessee Valley Authority	1977
*	–	1,175,000	Tennessee Valley Authority	1978

Figure 1. Nuclear power plants in the United States—continued

Reported Nuclear Detonations, May 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced two nuclear detonations for May 1972. These underground tests were in the low yield range (less than 20 kilotons TNT equivalent) and were conducted May 17 and 19, 1972, at its Nevada Test Site.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

*U.S. GOVERNMENT PRINTING OFFICE: 1973 514-153/211 1-3

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOLOGICAL SURVEYS OF PEARL HARBOR, HAWAII AND ENVIRONS. *Daniel F. Cahill, H. D. Harvey, Jr., D. C. McCurry. W. D. Breakfield, A. A. Moghissi, D. L. Norwood, N. E. Childs, J. E. Regnier. Radiation Data and Reports*, Vol. 14, June 1972, pp. 323–334.

From April 1966 through June 1968, the Eastern Environmental Radiation Laboratory of the Environmental Protection Agency (formerly the Southeastern Radiological Health Laboratory, Bureau of Radiological Health, U.S. Public Health Service) conducted radiological surveys of a number of U.S. ports which service nuclear-powered submarines. These surveys were undertaken to determine whether nuclear submarine operations, which include berthing, repair, and servicing, had resulted in radioactivity levels in the harbor which could contribute a detectable radiation exposure to the public.

Six surveys were conducted at five ports with histories of extensive nuclear vessel activities, namely: (1) Thames River, New London, Conn.; (2) Hampton Roads, Va. including Portsmouth, Norfolk, and Newport News, Va.; (3) San Diego Harbor, Calif.; (4) Mare Island Naval Shipyard, Vallejo, Calif.; and (5) Pearl Harbor, Hawaii.

This report describes the conduct of the onsite surveys performed at Pearl Harbor in 1966 and 1968 and presents the results of the laboratory analyses of numerous environmental samples which lead to the conclusion that:

(1) Small, but detectable, quantities of cobalt-60 were found exclusively in the sediment phases of the harbor;

(2) Neither the harbor water nor any other environmental samples contained detectable cobalt-60 activity;

(3) The total amount of cobalt-60 in the harbor sediment is small compared to the natural radioactivity present in Pearl Harbor and decreased significantly from 1966 to 1968;

(4) The levels of cobalt-60 activity in the harbor were well below levels that could contribute a detectable radiation exposure to the public and do not constitute a hazard to public health or the environment;

(5) Investigation of the physical and chemical characteristics of cobalt-60 in marine sediments indicates that cobalt-60 and possibly other neutron-activated corrosion products are released in a form which is not biologically available to marine or other forms of life.

KEYWORDS: Cobalt-60, marine sediments, nuclear vessels, Pearl Harbor, radiological surveys, water

RADIOFREQUENCY AND MICROWAVE RADIATION LEVELS RESULTING FROM MAN-MADE SOURCES IN THE WASHINGTON, D.C. AREA. *Stephen W. Smith and David G. Brown. Radiation Data and Reports*, Vol. 13, June 1972, pp. 335–345.

In order to determine the typical levels of radiofrequency and microwave radiation that result from man-made sources in an urban environment, measurements were made of peak power densities in the Washington, D.C. area during the summer of 1969. The highest levels measured (approximately 10^{-3} mW/cm^2) originated primarily from AM broadcast towers and airport radar installations.

KEYWORDS: Environment, microwave, radiofrequency, Washington, D.C.